

NOVEL AREAS OF CHEMICAL RESEARCH

Editor

Mrs. Suhada K M; M. Sc.

Assistant Professor, PG Department of Chemistry, KAHM Unity Women's College,
Manjeri, Narukara (PO), Malappuram (DT), PIN 676122 Kerala, India.

Published by

Mrs. Suhada K M; M. Sc.

Assistant Professor, PG Department of Chemistry, KAHM Unity Women's College,
Manjeri, Narukara (PO), Malappuram (DT), PIN 676122, Kerala, India.

ISBN:978-93-5701-222-5

© All rights reserved to the Editor.

First Edition

Printed at Apex Digital Services, Manjeri, PIN 676121, Malappuram (DT), Kerala,
India.



PG DEPARTMENT OF CHEMISTRY
KAHM UNITY WOMEN'S COLLEGE, MANJERI
Narukara (PO), Malappuram (DT), Kerala-676122, India

www.unitywomenscollege.in

E-mail: chemistry@unitywomenscollege.in

KAHM Unity Women's College was established in 1991 and is run by Muslim Educational and Cultural Association (MECA), a registered society. Started as a First Grade Aided College and affiliated to University of Calicut it is the only aided multi faculty (Arts, Science and Commerce) Women's College in Malappuram District. The institution aims at the upliftment of women in general and the educationally backward Muslim women in particular, through modern good quality education. The college has creditable academic as well as co-curricular accomplishments. The college has been accredited by NAAC at B* level (2.77) in 2019. The college offers 10 UG and 6 Pg courses.

Department of Chemistry was started in 1991 with Chemistry as subsidiary subject. Chemistry as main subject was started in 1993. 28 batches have successfully completed B.Sc. Chemistry Programme. The department conducted B.Sc. Industrial chemistry course in the vocational stream with the assistance of UGC during 1999-2004, Three batches completed the course. The Department became a Post Graduate Department in 2013 and became a Research Department in 2023. 8 batches have successfully completed the M. Sc. Chemistry Programme.

Our Vision:

- To develop a sense of intellectual curiosity concerning chemical theory and an appreciation of the practical role of chemistry in life.

Our Mission:

- To give a thorough grounding in the principle of chemistry, both in theory and in practical experience.
- To produce scientifically literate graduates and post graduates with a broad and deep knowledge of fundamental chemical principles.

© All rights reserved. No part of this publication may be reproduced, stored in or introduced into retrieval system or transmitted, in any form, or by any means, electronic, mechanical, photocopying recording or otherwise without the prior written permission of the publisher. Authors are solely responsible for the contents of the chapters in this volume. The editor has taken his best effort in the preparation of this book. Errors, if any, are purely unintentional and readers are requested to intimate the errors to the editor to avoid discrepancies in the future.

₹ 500

March 2023

ISBN:978-93-5701-222-5

CONTENTS

Chapter Number	Title and Authors	Page No.
1.	ESTIMATION OF OXALIC ACID IN SOME FRUITS AND VEGETABLES Dr. Muhammed Basheer Ummathur	4
2.	NOISE POLLUTION – CAUSES, EFFECTS, ASSESSMENT AND REMEDIES Dr. Jyothi P.	10
3.	APPLICATIONS OF Cu DOPED ZnO NANOPARTICLES Dr. Deepa K.	16
4.	WHAT HAPPENS TO MICROPLASTICS IN SOIL AND WATER? Mrs. Suhada K.M	21
5.	STRATEGIES TO PREVENT CORROSION Dr. Shamsheera K O	30
6.	MULTICOMPONENT REACTIONS FOR THE SYNTHESIS OF COMPLEX MOLECULES Dr. Jamsheena V	37
7.	SCAFFOLD DECORATED 1,2,3-TRIAZOLES AS POTENTIAL ANTI-CANCER AGENTS Dr. Thasnim. P* and Dr. Rajeena Pathoor#	43
8.	MESOPOROUS MATERIALS Mrs. Najeera P C	51
9.	NOVEL AREAS OF POLYMER RESEARCH Dr.Jasna V.C.	55
10.	STRONG LIGHT-MATTER COUPLING TO MODIFY CHEMICAL AND PHOTO-PHYSICAL PROPERTIES Mr. Muhammed Abdul Hakkeem C	60

ESTIMATION OF OXALIC ACID IN SOME FRUITS AND VEGETABLES

Dr. Muhammed Basheer Ummathur

*Principal and Professor, KAHM Unity Women's College, Manjeri, Kerala-676122,
India*

E-mail: mbummathur@gmail.com

INTRODUCTION

Oxalic acid is the simplest dicarboxylic acid and occurs as the dihydrate $C_2H_2O_4 \cdot 2H_2O$. It is a colourless crystalline solid soluble in water. It is a reducing agent and its deprotonated species, oxalate ion ($C_2O_4^{2-}$), is a chelating agent for metal cations¹. Its main applications include cleaning or bleaching, especially for the removal of rust due to the formation of a stable, water-soluble ferrioxalate ion. Hydrated lanthanide oxalates are formed readily in very strongly acidic solutions in a densely crystalline, easily filtered form, largely free of contamination by non-lanthanide elements. Thermal decomposition of these oxalates gives the oxides, which is the most commonly marketed form of these elements. Oxalic acid is required in our body for the formation of uracil and orotic acid².

More than 90 per cent of the oxalic acid consumed is normally excreted through urine. Organic form of oxalic acid, in low concentration, is essential to maintain peristaltic motion in our body. However, when it is processed or cooked, it becomes inorganic form, and may have certain negative effects on the body. Oxalic acid in concentrated form can have harmful effects through contact and ingestion. It is not identified as mutagenic or carcinogenic; there is a possible risk of congenital malformation in the fetus; may be harmful if inhaled, and is extremely destructive to tissue of mucous membranes and upper respiratory tract; harmful if swallowed; and causes burns if absorbed through the skin or is in contact with the eyes. Symptoms and effects include a

burning sensation, cough, wheezing, laryngitis, shortness of breath, spasm, inflammation and edema of the larynx, inflammation and edema of the bronchi, pneumonia and pulmonary edema. In humans, ingested oxalic acid has an oral LD_{Lo} (lowest published lethal dose) of 600 mg/kg. It has been reported that the lethal oral dose is 15 to 30 grams³.

ESTIMATION OF OXALIC ACID

Oxalic acid can be estimated by volumetry, colorimetry and chromatography. Volumetric estimation can be done by permanganometry. The oxalate ion is estimated volumetrically by titration with standard KMnO₄ solution in acid medium⁴.



In the colorimetric method, oxalate is co-precipitated with calcium sulphate and ethanol, reduced to glycolate by zinc and sulphuric acid and measured spectrophotometrically with chromotropic acid⁵.

Gas chromatography is a widely used method of oxalic acid estimation. Solid sample is extracted with water (soluble oxalic acid) or 2 N hydrochloric acid (total oxalic acid), at room temperature. An aliquot of sample extracted is evaporated to dryness. The oxalic acid in the residue is methylated with 7% hydrochloric acid-methanol. The reaction mixture is extracted with chloroform and dimethyl oxalate is quantitated by gas chromatography. The recovery of oxalic acid added to liquid samples averaged 100.6, such as recovery from extracts of solid sample were 96.2-99.5 and 97.2-100.1% for water and hydrochloric acid extraction, respectively⁵.

DETERMINATION OF OXALIC ACID CONTENT IN FRUITS AND VEGETABLES

Weigh accurately a definite amount of food sample using an electronic balance and grind well using a mortar and pestle. The ground food sample is transferred in to a beaker and add about 50 mL 4N dilute H₂SO₄ to it. The contents are boiled for about 10 minutes. Cooled and filtered in to a 100 mL standard flask. Added distilled water and solution is made up to the mark. The solution was shaken well for uniform concentration.

Pipette out 20 mL of the solution into conical flask. Added 20 mL of dilute H₂SO₄ solution and heated to bearable warm (60-70°C). The solution is titrated against standard KMnO₄ solution taken in the burette until the appearance of a permanent pale pink

colour⁵. The titrations are repeated till concordant values are obtained. From the titre value the normality of oxalic acid in the food sample can be calculated.

FRUITS



Grapes



Sapota



Guava



Mosambi



Orange



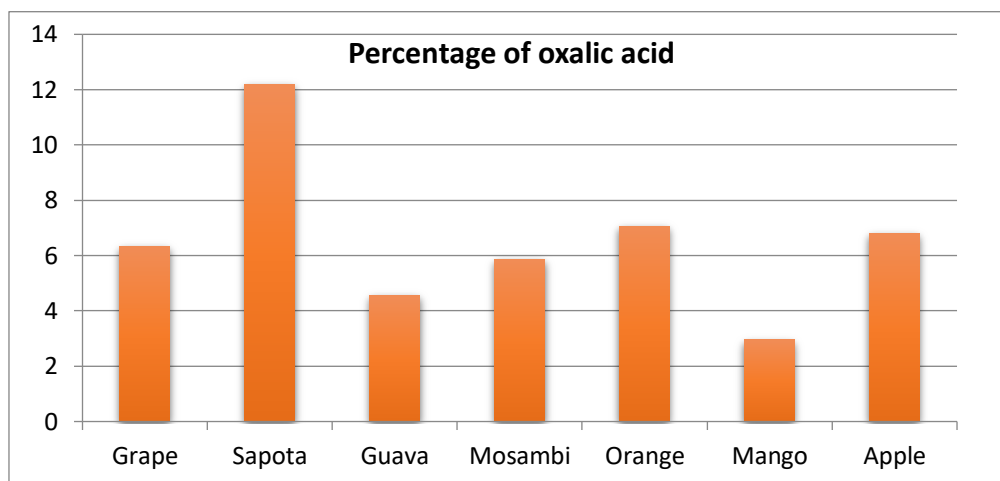
Mango



Apple

Table 1: Percentage of oxalic acid in fruits

<i>Sl. No.</i>	<i>Fruit</i>	<i>Weight (g)</i>	<i>Volume of KMnO₄ used (mL)</i>	<i>Percentage of oxalic acid</i>
1	Grapes	9.96	20.2	6.33
2	Sapota	4.92	19.2	12.19
3	Guava	14.6	21.3	4.55
4	Mosambi	10.82	20.3	5.87
5	Orange	9.86	22.3	7.06
6	Mango	23.11	22.0	2.95
7	Apple	10.12	22.0	6.79



Among the seven fruits studied the oxalic acid content is **highest in Sapota** and **lowest in Mango**. The percentage of oxalic acid in fruits follows the order; **Sapota > Orange > Apple > Grape > Mosambi > Guava > Mango**.

Among the seven fruits studied the oxalic acid content is highest in Sapota and lowest in Mango. The percentage of oxalic acid in fruits follows the order; Sapota > Orange > Apple > Grape > Mosambi > Guava > Mango.

VEGETABLES



Tomato



Cucumber



Green brinjal



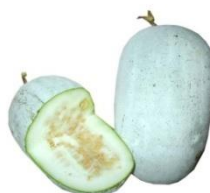
Beans



Violet brinjal



Snake gourd



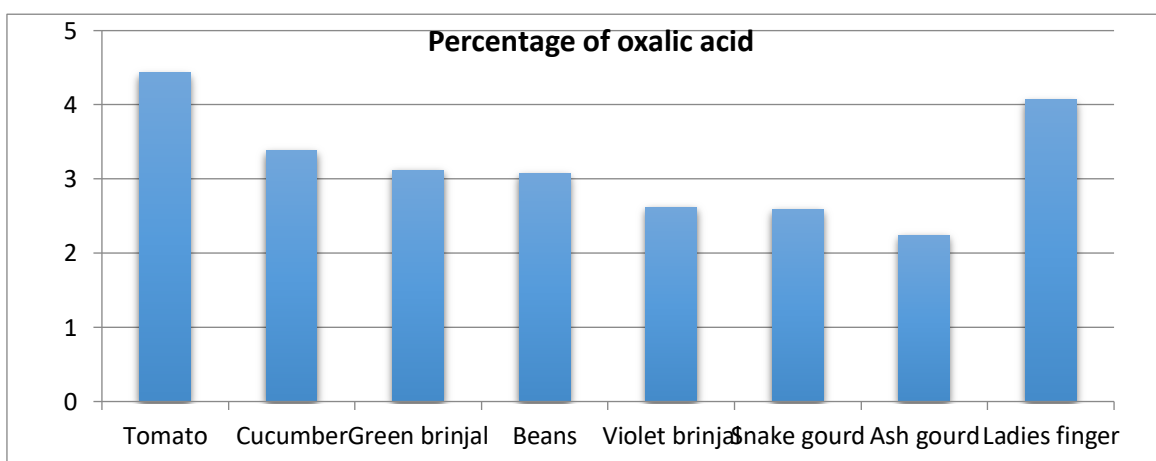
Ash gourd



Ladie's finger

Table 2: Percentage of oxalic acid in fruit vegetables

<i>Sl. No</i>	<i>Vegetable</i>	<i>Weight (g)</i>	<i>Volume of KMnO₄ used (mL)</i>	<i>Percentage of oxalic acid</i>
1	Tomato	13.84	19.6	4.43
2	Cucumber	21.91	23.8	3.39
3	Green brinjal	20.02	20.0	3.12
4	Beans	25.32	25.0	3.08
5	Violet brinjal	29.05	24.4	2.62
6	Snake gourd	26.53	22.0	2.59
7	Ash gourd	35.37	25.4	2.24
8	Ladie's finger	16.85	22.0	4.07



Among the eight vegetables studied the oxalic acid content is highest in Tomato and lowest in Ash gourd. The percentage of oxalic acid follows the order; Ash gourd < Snake gourd < Violet brinjal < Beans < Green brinjal < Cucumber < Ladie's finger < Tomato.

REFERENCES

1. L. G. Wade; *Organic Chemistry*, 8th Edition, Pearson, Boston, **2017**.
2. D. S. Robertson; The Function of Oxalic Acid in Human Metabolism, *Clin. Chem. Lab. Med.*, **2011**, 49(9), 1405-1412.
3. V. Veer and R. Gopalakrishnan; *Herbal Insecticides, Repellents and Biomedicines: Effectiveness and Commercialization*, Springer, **2016**.
4. J. Mendham, R. C. Denney, J. D. Barnes and M. Thomas; *Vogel's Textbook of Quantitative Chemical Analysis*, 6th Edition, Pearson Education, Noida, **2013**.
5. D. A. Skoog, D. M. West, F. J. Holler and S. R. Crouch; *Fundamentals of Analytical Chemistry*, 8th Edition Brooks/Cole, Thomson Learning, Inc., USA, **2004**.

NOISE POLLUTION – CAUSES, EFFECTS, ASSESSMENT AND REMEDIES

Dr. Jyothi P.

*Associate Professor and Head, PG Department of Chemistry, KAHM Unity Women's
College, Manjeri, Kerala-676122, India*

e-mail id: jyothipuramana@gmail.com

INTRODUCTION

The word Noise is derived from the Latin word “nausea” which means ‘unwanted sound’ or ‘sound that is loud, unpleasant or unexpected’. The noise is produced from human activities, especially the urbanization and the development of transport and industry. Though, the urban people are more affected by such pollution, small town or villages along side roads or industries are also affected by this problem. Noise is becoming an increasingly omnipresent, yet unnoticed form of pollution even in developed countries. Road traffic, jet planes, garbage trucks, construction equipment, manufacturing processes, and lawn mowers are some of the major sources of this unwanted sounds that are routinely broadcasted into the air. Though noise pollution is a slow and subtle killer, very little efforts have been made to control it. It along with other types of pollution has become a hazard to quality of life

CAUSES

Following are the main causes and sources of noise pollution:

1. Industrialisation:

Industrialisation has led to an increase in noise pollution as the use of heavy machinery such as generators, mills, huge exhaust fans are used, resulting in the production of noise pollution.

2. Events:

Weddings, public gatherings involve loudspeakers to play music resulting in the production of unwanted noise in the neighbourhood.

3. Construction sites:

Mining, construction of buildings, etc add to the noise pollution.

4. Vehicles.

Increased number of vehicles on the roads is a major reason for noise pollution.

EFFECTS

There are many an adverse effects of excessive noise or sudden exposure to noise. In India, the problem of noise pollution is wide spread. Several studies report that noise level in metropolitan cities exceeds specified standard limits. It is responsible for rising incidence of deafness among the inhabitants .A study by Singh and Mahajan conducted in Delhi and Calcutta, found that the noise level is 95dB as against the ambient limit of 45dB. Even at the “calm” places, it does not fall below 60dB. Another study by Murli and Murthy also found that traffic noise in Vishakhapatnam exceeds 90dB even in morning hours that acts as a source of nuisance.

Evidently, noise pollution has assumed alarming proportions affecting adversely the efficiency of various populations, mental health and general quality of life. Moreover, it is becoming a problem of law and order with the growing number of complaints to police and administration. Unless and until, measures are taken to control the level of noise, the ongoing urbanization and industrialization may complicate the problem so much that it becomes incurable .

The sound produced by a bursting cracker, exceeding 150dB, can cause a ringing sensation called ‘tinnitus’ and can impair hearing permanently. In general about 1 percent of the population suffers from noise-induced pollution. It is found that the noise level produced by household equipment and appliances sometimes reaches up to 97 dB which is more than double the acceptable (45dB) noise level. This excessive noise could carry several ill-effects viz. annoyance, speech interference, sleep disturbance, mental stress, headache, and lack of concentration. Similarly it is noted that the workers exposed to high noise levels have a higher incidence of circulatory problems, cardiac diseases, hypertension, peptic ulcers, and neurosensory and motor impairment. The adverse effects of noise have not even spare the birds and animals.

Noise pollution affects the physiological, neurological, endocrinological, and behavioural attributes of marine life. Anthropogenic noise causes sensory confusion, or masks communication among reef organisms for navigation, habitat selection, foraging, reproduction, and predator detection and avoidance

ASSESSMENT

Noise pollution is a major problem in urban environments, affecting human behaviour, well-being, productivity and health. The first step to be taken for controlling noise pollution is to assess the current noise climate by gathering real world data and building noise maps in order to better understanding of the problem and support the creation of local action plans.

1. Environmental noise assessment: Limitations of the current approach Nowadays assessments of environmental noise in urban areas are mainly carried out by officials who collect data at a sparse set of locations, e.g. close to roads, railways, airports and industrial estates, by setting up sound level meters during a short period of time. Propagation models are then used to generate noise maps by extrapolating local measurements to wider areas.
2. Alternative Approaches :
 - i) Wireless sensor network:

Recent years have seen an increasing interest in wireless sensor networks for environmental monitoring and urban sensing . A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor environmental conditions, such as temperature, sound, air pressure or air quality, at different areas.

- ii) Participation of citizens to implement the requirements :

This is especially important with regards to local action plans, which often directly affect people living nearby. But citizens can also contribute in earlier phases, such as during the actual assessment of noise pollution. In geography and urban planning there is a trend towards support for such participation. Under the flag of participatory GIS and participatory mapping new methodologies are being researched to better support the participation and involvement of citizens in projects that are typically tackled using

geographical information systems (GIS), such as the mapping of spatial phenomena or land use and urban planning.

iii) Mobile phone as an Environmental Sensor:

The growing popularity of smart phones with significant computational power, always-on Internet connectivity and integrated sensors (e.g. microphones, cameras, GPS, motion sensors) opens the door to a wide range of new applications. These devices represent a cheap but powerful WSN platform that is readily available and widely deployed. In this perspective mobile phones can serve as sensors which are carried by humans. This idea is closely related to the concept of participatory sensing which advocates the use of mobile devices to form sensor networks that enable public and professional users to gather, analyze and share local knowledge. At the same time, people as individuals or in groups can apply these new sensing networks with a more personal focus. Their individual stories of everyday life can be aggregated to document the urban environment, fed back into a collective experience in urban public spaces, enabling people-centric sensing for personal, peer or public purposes.

iv) Democratising noise pollution measurement:

“How much decibel am I exposed to now?” This kind of information is currently hard to obtain for a citizen. By turning smart phones into personal environmental instruments, we are essentially taking advantage of the democratisation of technology to achieve a democratisation of environmental information. Previous participatory sensing projects have been conducted in the context of a controlled, local and short-term monitoring by selected volunteers as a proof of concept. However, due to a lack of scale, the full potential of the participatory sensing paradigm in an environmental context has yet to be validated empirically by real world use. How will the practice of pollution monitoring change if not just few volunteers but every citizen has access to mobile environmental measuring devices? In the context of noise pollution, by turning mobile phones into noise pollution sensors, we strongly lower the entrance barrier of such environmental measurement technology. Noise Tube has the potential to set up new kinds of experiments by enlarging the scope of potential participants.

REMEDIES

There are several methods that can be utilized for controlling the level of noise. First of all, the design and technology of machines/ equipment could be altered resulting in low noise emission. Secondly, noise barriers may help us control noise. A third method is to protect receptors of sound by a shield e.g. building may be insulated against noise. Similarly, body and window planes may be made sound proof. Apart from technology, we may undertake various steps to modify or regulate the behaviour of users of machines and equipment. Though a legal framework could be enforced to regulate users of vehicles/equipment, but it requires huge resources and good governance. The public education appears to be a good option because it is a social problem. Sheer ignorance about the adverse effects of noise pollution appear to be a key factor in laying inadequate stress on controlling or reducing its levels. To make India a world-class destination for tourism, industry, and a place for healthy living, the development and implementation of a comprehensive noise control programme is a dire need of hour. This study identifies the sources of noise that create noise pollution. Moreover, the study explores the effects of noise on publics and their reactions. Finally, various measures to control the pollution are contemplated. The hazards increase with the intensity of the noise and the period of exposure.

The noise pollution is not a unique problem for developing countries like India. Several initiatives have been taken by various countries to check the noise level. For example, USA has taken initiative to create sit European Union (with more than 250,000 inhabitants) requires that 'noise maps' of big cities are drawn up by 2002 . To safeguard against ill effects of noise, the laws of Netherlands do not permit building of houses in areas where 24-hour average noise levels exceed 50dB. And in Great Britain, the Noise Act empowers the local authorities to confiscate the noisy equipment and fine people who create excess noise at night. Recently, several countries are also investing in 'porous asphalt' technology, which can curtail traffic noise by up to 5dB. The movement against noise pollution is weak in India. Most of the people were not considering it as a pollutant, and take it as a part of routine life. Later it has been recognized as a pollutant. In India, the Noise Pollution (Regulation and Control) Rules, 2000 have been framed under the Environment (Protection) Act, 1986. These are a set of guidelines for regulation and control of noise. A survey by Central Pollution Control Board (CPCB) shows that in Delhi, the noise level in most places exceeds the permissible limit. The average noise

level in Delhi is 80 dB while the ambient limit is 55dB . Bombay too suffers from high levels of noise pollution.

Furthermore, as is the case with many issues affecting the sustainability of life, noise pollution cannot be tackled by policymakers alone. To manage noise pollution in cities one also needs to consider the behaviour of the citizens themselves. The first step towards changing such behaviour is to raise awareness. It can be done by involving them in the process of monitoring noise pollution.

REFERENCES:

1. Singh, P.: Noise pollution. Every Man's Science. 25(1&2): 231-35 (1984).
The Times of India. New Delh
2. Nicolas Maisonneuve et al, Sony Computer Science Laboratory Paris, France
The Proceedings of the 10th International Digital Government Research
Conferencetic locations.
3. Hogan CM, Latshaw GL (May 21–23, 1973). *The relationship between highway planning and urban noise*. Proceedings of the ASCE Urban Transportation Division Environment Impact Specialty Conference. Chicago, Illinois: American Society of Civil Engineers. Urban Transportation Division.

APPLICATIONS OF Cu DOPED ZnO NANOPARTICLES

Dr. Deepa K

*Assistant Professor, Department of Chemistry, KAHM Unity Women's College,
Manjeri. Kerala-676122, India*

e-mail id: deepakarat08@gmail.com

INTRODUCTION

Cu-doped zinc oxide nanoparticles have been intensively studied because it has considerable potential for applying to wide range of applications, such as optical coatings, light-emitting diodes, laser diodes and catalysts. Recently, the unique properties demonstrated in Cu-doped zinc oxide nanoparticles have gained great interest for developing a wide range of advanced applications including field effect transistors [1, 2], field emission arrays, ultraviolet lasers, light emitting diode [3], sensors, biosensors [4, 5], catalyst [6], energy storage and solar cell [7]. The advanced functional properties of nanostructure materials are closely related to several factors such as high surface mass ratio, selective control surface terminal, different local structure from bulk and magnetic properties. For example, in Cu-doped zinc oxide, its magnetic property and band gap can be controlled by either changing its local structure or oxygen and/or Zn vacancies concentration by Cu¹⁺ and/or Cu²⁺ substitution interstitial of ZnO. The doping of metal ions in ZnO nanostructures can lead to effects such as enhancement/decrease in fluorescence and controlling concentration of surface defects. The doping of Cu in ZnO is expected to modify absorption, and other physical or chemical properties of ZnO because of the different structure of the electronic shell and the similar size of Cu and Zn. Cu can enter the ZnO lattice substitutionally as deep acceptors in combination with a neighbouring O vacancy.

APPLICATIONS OF Cu DOPED ZnO NANOPARTICLES**1. Application in Energy Conservation**

To provide sufficient energy for meeting human requirements is one of the challenges of 21st century and therefore emphasis is given on the development of alternative energy sources in different cost effective ways. Nowadays varieties of nanoparticles (NPs) are used as the new building blocks to construct light energy harvesting assemblies. New initiatives like use of bio-mimetic systems to simulate natural photosynthesis and fabrication of hybrid solar cells by using nanoparticles have been very promising.

Doping TiO₂, ZnO etc. with transition metals like Cu, Co, Ni, Au etc. have created new materials which have potential application in semiconductor devices [8]. The average size of nanoparticle found to be decreased as the doping percentage of copper metal is increased. The band gap values of prepared undoped and copper doped samples are found to decrease from 3.15 to 2.92 eV [9]. Optical absorption measurements indicate red shift in the absorption band edge upon copper doping. Studies shows that Cu doping has significantly and systematically influenced the band gap of ZnO by giving a strong green emission in the visible luminescence region, which is potentially important for photocatalyst and solar cell devices. Using Cu doped ZnO NPs in specially designed electrochemical cell can utilize the heat energy of sun as opposed to traditional light quanta. The new material upon thermal excitation generates voltage of useful magnitude (maximum of ~ 632 mV) and energy conversion efficiency (maximum of 1.36%) with sufficient storage capability (~ 47 hrs). This heat induced voltage generation of Cu-doped ZnO NPs will definitely lead to new possibilities for harvesting thermal energy coming from sun even in cloud covered days or from any other sources, for example, from industrial wasted heat [10].

2. Applications in Photocatalysis

For photocatalysis, ZnO has also been considered as a suitable alternative for TiO₂ due to its similar band and lower cost. Moreover, it exhibits better performance in the degradation of organic dye molecule in both acidic and basic media. The intrinsic defects of ZnO are beneficial for setting up catalytic systems, which are expected to degrade the environmental contaminants. It has been widely proved that modifications of oxide semiconductors, including doping of transition metals or rare earths, could enhance their properties. The photocatalytic properties of ZnO were greatly enhanced when modified with the incorporation of dopant ions. The surface defects caused by Cu doping could serve as favourable trap sites of the electrons or holes to reduce their recombination and consequently increase the photocatalytic activities. Furthermore, a bigger surface to volume ratio in

nanorods results in more surface oxygen vacancies and thus increased surface activity. The Cu-doped ZnO nanorods has found to exhibit good photocatalytic activity for organic pollutants in water and has potential use in wastewater treatment [11].

3. Gas sensing applications

It is well known that many dangerous substances are emitted into the atmosphere, mainly due to industrial activity and the accelerated urbanization in the last decades hence, the use of gas sensors to detect and monitor these substances is essential. Studies on gas sensors based on metal oxide semiconductors specifically chemical sensors, play an important role in the development of sensing devices used for controlling the toxic gases in the environment, that is why in recent years, there has been an increase in the development of sensors with high performance in their response magnitude and selectivity; additionally, a low manufacturing cost. ZnO has been studied in its various structures, such as nanorods used in gas sensors to detect ethanol, with a high reversible and rapid response to reducing ethanol. Nanotubes used to detect nitrogen dioxide, showing excellent detection capacity with a response of 500 ppm at 30 °C. Nanowires were manufactured for interaction with various gas environments, identifying a significant influence on the detection of carbon monoxide, and highly sensitive gas sensors in ethanol detection. Nanoparticles were connected to each other forming ZnO chains for the detection of NO₂, H₂ and CH₄ reflecting a high and reversible response in chemical sensors. Studies showed that Cu doped ZnO nanoparticle powders present a small size that is suitable for manufacturing gas sensors, as the area/ volume ratio is high. The pellets' sensitivity improved markedly with the doping process. Cu doped ZnO pellets has been found to show highest sensitivity towards propane gas absorption [12].

4. Application as Light Emitting Diodes

ZnO as a promising candidate for the development of light-emitting structures and lasers for the blue and ultraviolet. ZnO has high surface to volume ratio at nanometer scale and hence surface defects play an important role in its properties. The effect of Cu doping as a luminescence activator and as a compensator of n-type material is of great importance for semiconductors. The emission spectra of Cu doped ZnO extend from ultraviolet to infrared region depending on the defects in ZnO, excitation conditions, and concentration of Cu. In the past few years, much efforts were made in the field of synthesis of ZnO to devise an approach that is compatible with the current device fabrication technologies, which should be simple, low cost, and should be suitable for mass-scale production. Studies revealed that

the copper doped ZnO nanoparticles are possess enhanced photoluminescent property along with unique optical and structural properties. Thus, high percentage of green photoluminescent copper (0.3%) doped ZnO nanoparticles are proposed to be useful in the fabrication of white LEDs with broad-band visible phosphors. Currently, light-emitting diodes (LEDs) giving green light emission have been combined with broad-band visible phosphors to make white-light LEDs. Thus, green photoluminescent ZnO:Cu nanophosphors are seen as necessary and condemnatory constituent for white-light LEDs[13].

CONCLUSION

Properties of pure ZnO nanoparticles can be tuned by doping and tailoring the processing parameters associated with synthesis process making it viable for various applications. Doped ZnO nanostructures are multifunctional materials which can exhibit photocatalysis in aqueous medium for deterioration of various exotic dyes released into water bodies by industries with or without illuminating, generating hydrogen which can solve energy as well as environmental issues, sense toxic gases, assist in development of cheap and efficient solar, fuel cells and play an important role in the field of spintronics, medicine, photoluminescence. Copper-doped ZnO nanoparticles are highly beneficial in several applications due to the profound improvement in the physical and chemical properties of the obtained nanoparticles.

REFERENCES

1. Karamat S, Rawat R S, Tan T L, Lee P, Springham S V, Anis-ur-Rehman, Chen R and Sun H D 2013 J. Supercond. Nov. Magn. 26 187.
2. Elilarassi R, Sambasiva R P and Chandrasekaran G 2011 J. Sol-Gel Sci. Technol. 57 101.
3. Kim J B, Byun D, Je S Y, Park D H, Choi W K, Choi J-W and Angadi B 2008 Semicond. Sci. Technol. 23 095004.
4. Chow L, Lupan O, Chai G, Khallaf H, Ono L K, Roldan C B, Tiginyanu I M, Ursaki V V, Sontea V and Schulte A 2013 Sensors Actuators A 189 399.
5. Zhou C, Xu L, Song J, Xing R, Xu S, Liu D and Song H 2014 Sci. Rep. 4 7382.
6. Poonam B, Anindita D, Ruma B, Sukhen D and Papiya N 2014 Curr. Appl. Phys. 14 1149.
7. Mohammad H H, Bahareh K, Mahmoud Z and Mehdi H 2014 J. Ind. Eng. Chem. 20 1462.
8. M. Fu, Y. Li, S. Wu, P. Lu, J. Liu, F. Dong., 2011 Appl. Surf. Sci. 258 1587.

9. Muhammad Sajjada,, Inam Ullaha, M.I. Khanb, Jamshid Khanc , M. Yaqoob Khana , Muhammad Tauseef Qureshi 2018 Results in Physics, 9 1301.
10. P. Bandyopadhyay, A. Dey, R. Basu, S. Das, P. Nandy, 2014 Current Applied Physics 14 8 1149.
11. R. Mohan, K. Krishnamoorthy, S.J. Kim, 2012, Solid State Commun. 152 375.
12. Herrera-Rivera, R., Morales-Bautista, J., Pineda-Reyes, A. M., Rojas-Chávez, H., Maldonado, A., Vilchis, H., ... Olvera, M. de la L. 2020 Journal of Materials Science: Materials in Electronics, 32 133.
13. Aravapalli Vanaja, Suresh, M., Jeevanandam, J., Venkatesh, Gousia, S., Pavan, D., Murthy, N. B. 2019 Protection of Metals and Physical Chemistry of Surfaces 55 3, 481.

WHAT HAPPENS TO MICROPLASTICS IN SOIL AND WATER?

Mrs. Suhada K.M

*Assistant Professor, PG Department of Chemistry, KAHM Unity Women's College,
Manjeri, Kerala-676122, India*

e-mail id:kmsuhada591989@gmail.com

INTRODUCTION

Microplastic pollution in soil refers to the accumulation of tiny plastic particles in the soil environment. These particles can range in size from 5mm to less than 1 micron and come from a variety of sources including consumer products, agricultural and industrial practices. Microplastics have been found in many different environments, including the oceans, freshwater systems, and even in the soil.

In soil, microplastics can negatively impact plant growth and soil health, leading to reduced biodiversity and decreased crop yields. They can also contaminate the food chain by being taken up by plants and ingested by wildlife, including livestock and humans. Additionally, microplastics can absorb and release toxic chemicals, such as persistent organic pollutants, which can further harm the environment and wildlife.

Given the widespread distribution and persistent nature of microplastics, it is crucial to reduce their use and release into the environment through improved waste management practices, the use of alternative materials, and increased public awareness. Efforts to mitigate microplastic pollution in soil will require a multidisciplinary approach that engages scientists, policymakers, and the public in finding sustainable solutions.

ENVIRONMENTAL FATE OF PLASTIC ADDITIVES IN THE PLASTIC DEBRIS OR MICROPLASTICS

Plastic additives represented one of the most important organic pollutants associated with microplastics; the types, quantification, and migration from the plastic debris or microplastics are addressed here. In addition to the chemical additives, microplastics also

adsorbed hydrophobic or hydrophilic organic pollutants from the environments due to their high surface areas and affinity for these pollutants. The sorption affinity changed by the aging of microplastic surface was of concern in particular. The organic pollutants in the microplastics may cause toxic effects on biotas by releasing into the leachate or by contact exposure directly through microplastics ingestion. Here we reviewed the latest reports on the organic pollutant assay for the leachates from the environmental microplastics and their toxic effects on freshwater species *Daphnia magna*, brown mussel (*Perna perna*), barnacle, and microalgae using different endpoints. Bioaccumulation of organic pollutants and biological toxicology through the vector effects of microplastics were also reviewed in the paper. However, large uncertainties existed among the different studies with respect to the toxic effects of co-exposure with organic pollutants and microplastics. Therefore, further researches are recommended to be done regarding the combined effects of organic pollutants and microplastics under the different exposure scenarios.

MIGRATION AND RELEASE OF CHEMICAL ADDITIVES FROM THE PLASTIC DEBRIS OR MICROPLASTICS

The additives can potentially migrate and be released from polymers during the exposure in environments. Therefore, it is of great interest whether organic chemicals from plastic debris or microplastics cause serious environmental risks. Until now, the majority of studies on the migration and fate of plastic additives associated with plastic particles have focused on leaching of flame retardants, plasticizers, and fluorescent additives.

OCCURRENCE OF ORGANIC POLLUTANTS IN THE ENVIRONMENTAL MICROPLASTICS

Studies on the organic pollutants in the environmental microplastics started from monitoring of persistent organic pollutants (POPs) in the plastic resin pellets (small granules 0.1–0.5 cm in diameter). A range of organic micro-pollutants (including polychlorinated biphenyls (PCBs), DDE, and nonylphenol) have been detected in plastic resin pellets stranded on beaches.

The concentration of organic pollutants in the plastic resin pellets was found having a relationship with the aging time of the pellets in environment. Fifty-five resin pellets from a beach in Tokyo were individually analysed for PCBs and showed discoloured (e.g.,

yellowing) pellets contained more PCBs than others on most of the beaches sampled. Analogous to the results in Tokyo beach, aged and black pellets were also measured higher concentrations for the PCBs, PAHs, and DDT in the beaches of the Portuguese coast. The increase of adsorption of POPs in the plastic pellets with the aging time may result from the increase of specific surface areas and crystallinity after a long-term exposure in environment.

Hydrophobic organic pollutants in microplastics

Microplastics were found having a high affinity for hydrophobic organic pollutants (HOCs) due to their high hydrophobicity and specific surface area. Sorption of HOCs by plastic polymers was mainly governed by hydrophobic interaction mechanism. Liu et al. For the polymers (e.g., PS) with benzene rings in their structure, π - π interaction was supposed to be one of the most important mechanisms for their strong sorption for HOCs. In the same study, the higher sorption of DEP and DBP by PS compared to PE could be resulted from the strong π - π interactions between PS and the two PAEs. The previous study also revealed that sorption of PAH to virgin polystyrene microplastics was higher compared to sorption to nonaromatic polyethylene, polyvinyl chloride, and polypropylene microplastics due to the strong π - π interactions between the PS and PAHs. Velzeboer et al. suggested that the strong sorption of PCBs to nano-PS particles in their experiment could be explained by both hydrophobic and π - π interactions. Sorption experiment with nano-PS and PAHs indicated that the adsorption isotherms were nonlinear and a high distribution coefficient up to 109 L/kg was obtained as a result of the π - π interactions between the planar PAH and the surface of the aromatic polymer polystyrene.

Sorption of HOCs to microplastics might be limited by diffusion in the plastic phase, which could be described as biphasic process, the fast sorption/desorption in the outer layer followed by slow diffusion into the inner plastic phase. This biphasic model is frequently used for sorption of HOCs to soils or sediments. A recent study showed that the sorption process of HOCs to the micro-sized PS included two stages: the fast sorption stage for the HOCs diffusing through aqueous boundary layer and the slow one for the HOCs penetrating inside the PS particle, while the mass transfer rates were extremely slow for the second sorption phase.

Several factors have impacts on the sorption of HOCs onto the microplastics. In terms of the plastic polymers, physical structures have been found to play an important role in the HOC sorption. Guo et al. examined the sorption behavior of four hydrophobic organic contaminants by the different polymers and found that the organic carbon content-normalized sorption coefficients (K_{oc}) of phenanthrene, lindane, and naphthalene by PEs of same composition but distinct physical makeup of domains increased with their crystallinity reduction.

Weathering in environments of the microplastics changes their surface properties and hence alters their sorption behavior for HOCs. The weathered plastics would increase the adsorption capacity than virgin plastics. This might be mainly attributed to the increase in surface area due to polymer weathering that would increase the effective diffusivity and the additional sorbents attached to the plastic debris for hydrophobic contaminants. An increase in the surface area due to weathering could also increase polarity of the polymer surface by introducing oxygen-containing groups, which could decrease the affinity for hydrophobic compounds. Sorption coefficients of naphthalene by polystyrene microplastics following aging were found up to one order of magnitude lower than for pristine particles.

External factors, such as temperature, salinity, and composition of the water phase (e.g., particulate and dissolved organic matter), can also influence the sorption behavior of HOCs by microplastics in waters. The temperature has an impact on the sorption of HOCs in the microplastics through changing the surface tension of solution and the solubility of HOCs in the solution. Zhan et al. observed that increasing temperature decreased the sorption of PCB by PP in pure water. The salinity would impact the solubility of hydrophobic organic compounds by natural sorbents such as soils, clays, and sediments. Recent experiment results revealed that the sorption capacity of PCB, phenanthrene, and PAEs in the simulated seawater is higher than those in the ultrapure water, which indicates that salinity acts as one main factor affecting sorption capacity.

Hydrophilic organic pollutants in microplastics

Compounds with more hydrophilic properties have been much less considered in comparison to the highly hydrophobic compounds with respect to their adsorption and desorption in the microplastics. Pharmaceuticals and personal care products (PPCPs), as emerging contaminants (ECs) in terrestrial environments, threaten the aquatic and soil

resources. Most of the PPCPs have hydrophilic properties and have a high possibility of interacting with microplastics, especially aged microplastics, because of their hydrophilic, oxygen-containing functional groups. The mechanism governed adsorption of pharmaceuticals in the microplastics included the partitioning, electrostatic interactions, intermolecular hydrogen bonding, and π - π interactions. A study regarding the adsorption of antibiotics on the different types of microplastics showed that the adsorption capacities of ciprofloxacin (CIP), trimethoprim (TMP), and sulfadiazine (SDZ) on PS are higher than those on PE, suggesting the π - π interactions dominated the adsorption of the three antibiotics at the aromatic surface of the PS. In another study which examined the adsorption of oxytetracycline to microplastic polystyrene, the results revealed that electrostatic interaction regulated the adsorption; meanwhile H-bonding and multivalent cationic bridging mechanisms may also have affected the adsorption. Aging has a pronounced effect on the adsorption enhancement by microplastics owing to the increasing of surface areas, hydrophilic properties of the surface, and oxygen-containing functional groups after aging.

Impacts of pH, ionic strength, and dissolved organic on the adsorption have been examined in the present studies. In contrast to the negligible effects of pH on the adsorption of HOCs by microplastics, the solution pH has a pronounced effect on the antibiotic adsorption by microplastics because various antibiotics will exhibit different speciation of the cation, zwitterion, and anion in a specific pH condition.

Ionic strength of the solution plays an important role in the regulation of antibiotic adsorption by microplastics. Usually, a reduction of adsorption will be observed with the increasing of ionic strength owing to the competing with antibiotics on the adsorption sites on the plastic surface. However, the ions of different valence state may have different influence on the adsorption. The depression of oxytetracycline sorption to the aged PS foams can be offset in the presence of Ca^{2+} through formation of ternary complexes between the cations and oxytetracycline and the surface functional groups.

The effects of DOM on the antibiotic adsorption were not consistent among the different studies. Xu, Liu, Brookes, and Xu found the increasing concentration of fulvic acid inhibited the sorption of tetracycline on three microplastics, decreasing them by more than 90% at the fulvic acid concentration of 20 mg/L. However, in the study of Zhang et

al. both fulvic acid and humic acid promoted the adsorption of oxytetracycline in the aged PS foams, and humic acid has more pronounced effect than fulvic acid.

INTERACTION OF MICROPLASTICS AND HEAVY METALS

The toxicity of MPs to terrestrial organisms, such as earthworms, mice, and other, has been conducted. It has been confirmed that MPs with particle size less than 1 mm are easily ingested by soil organisms. Lwanga et al. found that MP exposure could affect the growth and movement of earthworm *Lumbricus terrestris* (*L. terrestris*). The results showed that microorganisms in the earthworm gut significantly decreased low density polyethylene (LDPE) particle size. Other studies have also shown the toxic effects of various MPs on other soil organisms. Furthermore, particle size is one of the most important characteristics of MPs toxicity. For example, 1 μm is the most common size of filter food organ interception in crustaceans, so crustaceans prefer to ingest MPs with particle size less than 1 μm . Smaller particles have a greater possibility of biological intake than larger size particles, which may enter the cells through endocytosis. Although it has been assumed that the toxicity of MPs is significantly related to its particle size, there is no unified view on what kind of particle size MPs is more toxic. The toxic effects of 0.05 μm , 0.5 μm , and 6 μm MPs on rotifer *Brachionus koreanus* were compared, and it was concluded that small particle size MPs had more significant toxic effects. The antioxidant enzyme activity and mitogen-activated protein kinase (MAPK) signaling pathway in rotifer changed with different particle size of MPs. Likewise, another study found that MPs with particle size larger than 50 μm had no significant toxic effect on Grass shrimp (*Palaemonetes pugio*), while the fatality rate of acute toxicity test was higher when the size less than 50 μm . It was indicated that MPs have size-dependent effects on the same species.

The interaction between MPs and other pollutants is present in the environment. Therefore, in order to evaluate the ecological risk of MPs, the interaction between MPs and other pollutants should be considered, and the toxic effects of combined exposure on various organisms should be addressed. However, there is still lack of research on the toxic effects of MPs in combination with other pollutants, especially MPs and heavy metals. There are only a few articles published that deal with the combined toxic effects of MPs and heavy metals. Combined exposure of Cr^{6+} and MPs enhanced the toxicity of the juveniles of common goby – *Pomatoschistus microps* and caused strong lipid

peroxidation damage in larvae. By contrast, another study has shown that the combined exposure of 1 μm MPs and Cu to microalgae did not show any toxicity. These studies showed that the combined exposure of MPs and heavy metals is affected not only by the particle size but also by the selected biological species. Moreover, MPs can also interact with heavy metals in the soil environment. Hodson et al. studied the adsorption behavior of high density polyethylene (HDPE) on Zn^{2+} in soil. They found that HDPE had stronger adsorption capacity for Zn^{2+} in soil with more abundant organic matter. The adsorption behavior was in accordance with Langmuir and Freundlich equation. The aged MPs in soil also had a significant effect on the adsorption of heavy metals. Nicole et al. exposed HDPE, polyvinyl chloride (PVC), and polystyrene to artificial aging conditions (2000 h, photo-oxidation and thermal oxidation) to simulate their aging process using a column percolation test. Their results showed that the aged MPs not only significantly increased the adsorption of TOC, Cl, Ca, Cu, and Zn but also weakened the desorption and release of heavy metals, which indicated that the aged MPs had stronger fixation ability to heavy metals. In addition, the functional groups in the soil are adsorbed to the surface of the MPs and may change the adsorption capacity of heavy metals. Kim et al. investigated the adsorption of Ni by the functional group-coated polystyrene. Results showed that the functional groups change the surface hydrophobicity of the polystyrene microplastic and heavy metal and then alter the adsorption of the heavy metal. Turner et al. also studied the adsorption properties of polyethylene microplastics (PE-MPs) for heavy metal ions (Ag, Cd, Co, Cr, Cu, Hg, Ni, Pb, and Zn). The adsorption kinetics experiments showed that the adsorption efficiency of aged PE-MPs in river water was higher than that of original PE-MPs, which may be due to the change of the surface structure of aged PE-MPs to reach surface charge equilibrium. Holmes et al. also found that the adsorption capacity of aged polyethylene in seawater for heavy metals was stronger than that of the original polyethylene. Therefore, once the MPs in the soil are weathered and aged, they can be effective carriers of heavy metal in the soil environment what can cause even greater damage to the health of the soil ecosystem.

CONCLUSION

Microplastics are small plastic particles that are less than 5mm in size. These particles can come from various sources such as microbeads in personal care products, plastic fibres from clothing, and plastic fragments from larger items that have broken down over time.

When MPs enter soil and water, they can have a number of different impacts depending on their size, shape, and chemical composition. Microplastics can accumulate in soil and water over time. This can lead to the build-up of these particles in the environment, which can have negative impacts on the ecosystem. Microplastics can be transported by water and wind, which can cause them to move from one location to another. This can lead to contamination of new areas and can also impact the distribution of microplastics in the environment. Microplastics can contain additives and chemicals that can leach into soil and water. These chemicals can have negative impacts on soil and water quality and can also affect the health of organisms that live in these environments. Microplastics can affect the structure of soil by altering its physical properties. This can impact the ability of soil to hold water and nutrients, which can affect plant growth and soil fertility. Overall, microplastics can have a number of negative impacts on soil and water quality. As such, it is important to reduce the use of plastic products and to properly dispose of plastic waste to help prevent the build up of microplastics in the environment.

REFERENCES

1. Six, J., Conant, R. T., Paul, E. A. & Paustian, K. Stabilization mechanisms of soil organic matter : Implications for C-saturation of soils. 155–176 (2002).
2. Piccolo, A. The supramolecular structure of humic substances: A novel understanding of humus chemistry and implications in soil science. *Adv. Agron.* **75**, 57–134 (2002).
3. Schaumann, G. E. & Thiele-Bruhn, S. Reprint of: Molecular modeling of soil organic matter: Squaring the circle? *Geoderma* **169**, 55–68 (2011).
4. Schneckenburger, T. *et al.* Organic Geochemistry Preparation and characterization of humic acid cross-linked with organic bridging groups. *Org. Geochem.* **47**, 132–138 (2012).
5. Weber, W. J. A Distributed Reactivity Model for Sorption by Soils and Sediments . 8 . Sorbent Organic Domains : Discovery of a Humic Acid Glass Transition and an Argument for a Polymer-Based Model. **31**, 1697–1702 (1997).
6. Pignatello, J. J. Dual-Mode Sorption of Low-Polarity Compounds in Glassy Poly

- (Vinyl Chloride) and Soil Organic Matter. **31**, 792–799 (1997).
7. Wershaw, R. L. A new model for humic materials and their interactions with hydrophobic organic chemicals in soil-water or sediment-water systems. *J. Contam. Hydrol.* **1**, 29–45 (1986).
 8. Hu, C., Liu, Y., Smestad, B., Petersen, D. & Klaveness, D. Extracellular carbohydrate polymers from five desert soil algae with different cohesion in the stabilization of fine sand grain. **54**, 33–42 (2003).
 9. Piccolo, A. & Conte, P. Molecular Size of Humic Substances. Supramolecular Associations Versus Macromolecular Polymers. *Adv. Environ. Res.* **3**, 508–521 (1999).
 10. Piccolo, A. & Mbagwu, J. S. C. Role of Hydrophobic Components of Soil Organic Matter in Soil Aggregate Stability. *Soil Sci. Soc. Am. J.* **63**, 1801–1810 (1999).
 11. Patrakov, Y. F., Semenova, S. A., Fedorova, N. I., Ivanov, D. P. & Dubkov, K. A. Modification of the Organic Matter of Brown Coals with Nitrous Oxide. **46**, 159–163 (2012).
 12. Pru, A., Schaumann, G. E. & Grebi, L. Hydration of humic and fulvic acids studied by DSC. 451–459 (2012) doi:10.1007/s10973-011-2178-1.
 13. Burauel, P. & Fu, F. Formation and long-term fate of non-extractable residues in outdoor lysimeter studies. **108**, 45–52 (2000).
 14. Wrobel, K., Sadi, B. B. M., Wrobel, K., Castillo, J. R. & Caruso, J. A. Effect of Metal Ions on the Molecular Weight Distribution of Humic Substances Derived from Municipal Compost : Ultrafiltration and Size Exclusion Chromatography with Spectrophotometric and Inductively Coupled Plasma-MS Detection. **75**, 761–767 (2003).
 15. Lou, X., Zhu, Q., Lei, Z., Dongen, J. L. J. Van & Meijer, E. W. Simulation of size exclusion chromatography for characterization of supramolecular complex : a theoretical study. **1029**, 67–75 (2004).

STRATEGIES TO PREVENT CORROSION

Dr. Shamsheera K O

*Assistant Professor, Department of Chemistry, KAHM Unity Women's College,
Manjeri. Kerala-676122, India*

e-mail id: shamsimanu@gmail.com

Corrosion has been the subject of scientific study for more than 150 years. Humans have been trying to understand, control, and prevent corrosion for as long as they have been using metal objects. Corrosion never stops but its severity can be controlled by various methods either by isolating the metal from the aggressive environment or elimination of any one of the components of electrochemical cells which accelerates the corrosion process. The general classification of various corrosion prevention methods is summarized in Figure 1

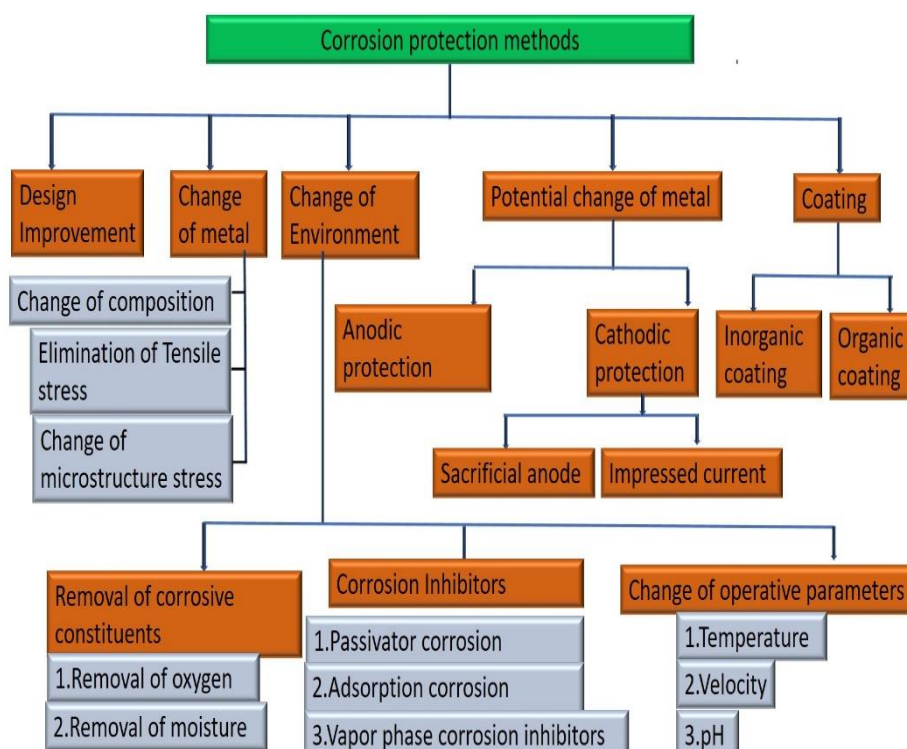


Figure 1. Corrosion prevention methods

1. CORROSION INHIBITORS

Changing the environment by adding corrosion inhibitors (CI) is considered as an efficient corrosion management method^[1]. A corrosion inhibitor is a chemical substance which when added in a small concentration to the corrosive environment results in a significant reduction in the corrosion rate either by reducing the rate of attack or by reducing the probability of its occurrence or by both^[2]. An efficient inhibitor should be economical, environment friendly, and inhibit the corrosion process when present in a small concentration. Corrosion prevention using inhibitors has some noticeable advantages such as low cost, simple control and operation, and non-requirement of special instruments^[3]. Corrosion inhibition is achieved in two ways. In some cases, the inhibitor interacts with the metal surface and forms an inhibitive surface film at the metal/electrolyte interface (Figure. 2).

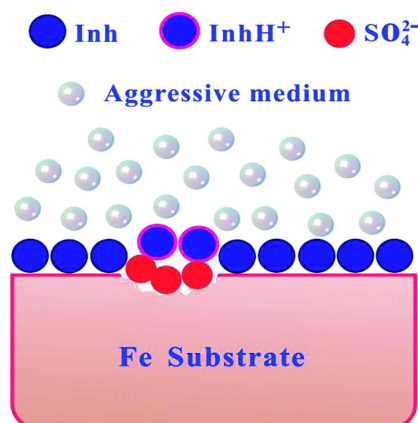


Figure. 2. Mechanism of Inhibition

In other cases, the inhibitor can alter the corrosive environment into a less corrosive or noncorrosive environment, e.g. by chemically neutralizing dissolved acidic gases, chemically scavenging dissolved oxygen, etc. Thus, based on the mode of interaction a qualitative classification of CI is presented in Figure.3^[4].

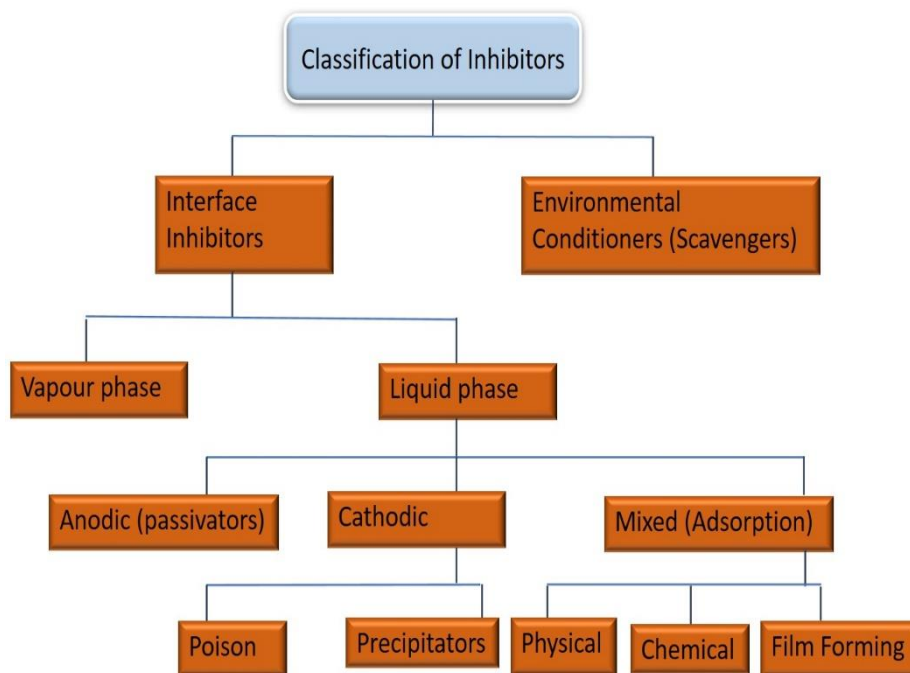


Figure 3. Classification of corrosion inhibitors

Environmental conditioners or scavengers control the corrosion process by decreasing the corrosivity of the medium through scavenging the aggressive substances. In near neutral and alkaline solutions, the cathodic oxygen reduction can be controlled by decreasing the oxygen content using scavengers ^[5]. In a boiler system, hydrazine is used as a scavenger to remove traces of oxygen ^[6]. Interphase inhibitors prevent the corrosion process by forming a film at metal/environment interphase. Substances having low vapour pressure with corrosion inhibiting capacity are used as vapour phase inhibitors (VPI) against atmospheric corrosion, especially in a closed environment. In boilers, VPIs prevent corrosion in condenser tubes by neutralising the acidic CO₂. Volatile inhibitors of this type transported to the corrosion site and inhibit the corrosion process by maintaining the atmosphere alkaline ^[7].

LPIs are classified as cathodic, anodic, or mixed type inhibitors, based on whether they inhibit the anodic, cathodic, or both the electrochemical corrosion process. Anodic inhibitors develop a protective oxide film on the surface of the metal and causing a large anodic corrosion potential shift and thereby force the metal surface into the passivation region and hence commonly referred to as passivators. If the concentration of anodic inhibitors is not enough to block off all the anodic sites, the oxidising nature of the inhibitor encourages the anodic reaction and results in pitting corrosion. So, they are

classified as dangerous inhibitors and chromates, tungstate, molybdates, nitrates, etc are belonging to this category.

Cathodic inhibitors inhibit the corrosion process by either decreasing the cathodic reduction rate or by selectively precipitating an insoluble species onto the cathodic sites to limit the diffusion of reducing species to the metal surface. They are belonging to safe inhibitors because they do not cause localised corrosion. Zinc ions are used as a cathodic inhibitor by precipitating $Zn(OH)_2$ at the cathodic site in the cathodic oxygen reduction process.

Mixed (adsorption) inhibitors work by reducing the anodic and cathodic corrosion reactions. Many inhibitors work by adsorption on the metal surface. Adsorption depends on the surface charge of the metal atom, structure of the inhibitor, and type of the electrolyte. Adsorption inhibitors offer corrosion inhibition via physisorption, chemisorption, and film formation. Physisorption by the electrostatic interaction between the metal atom and the inhibitor is removed from the surface of the metal on increasing the temperature. Chemisorption due to charge sharing or charge transfer between the metal and inhibitor molecules is more effective and not completely reversible [8]. The adsorption can be represented as



The extent of adsorption depends on the nature of the metal, the chemical structure of the inhibitor, the mode of adsorption, and the type of corrosive medium. The exact nature of adsorption can be verified from adsorption isotherms which describe the surface coverage (θ) by the inhibitor on the metal surface and the concentration of the inhibitor.

2. SYNERGISM AND CORROSION INHIBITION

Synergism is an adequate method for enhancing the corrosion inhibition performance of an inhibitor especially at elevated temperatures. It can be defined as the marked augmentation of the corrosion inhibition performance of one inhibitor by adding a small amount of another inhibitor, even though the second inhibitor is less effective when used separately. Co-adsorption of two or more molecules onto the metal surface provide better inhibition than either of the individual components. Speller et al reported that the corrosion inhibition performance by phosphate-chromate mixtures is found to be more effective than their individual performance. The method of using two or more inhibitors

together via synergistic interaction, is an effective method of enhancing the corrosion inhibition. Here the quantity of the inhibitors can be considerably reduced without compromising efficiency of inhibition.

3. CORROSION RESISTANT COATINGS

Corrosion protection by coating has attracted much attention due to its high efficiency and durability in various aggressive environments^[9]. The durability and performance of corrosion resistant coatings depend on many factors such as type of metallic substrate, pre-treatment of metal, curing, adhesion between the metal and the coating, the thickness of the coating, etc^[10]. An effective coating must have intrinsic durability, adhesion with the metal substrate, toughness to survive cracking and keep its appearance when subjected to stress, swell, or weathering^[11]. An anti-corrosive system for a highly corrosive environment usually consists of a primer, one or several intermediate coats, and a topcoat^[12]. The primer ensures good adhesion to the metallic substrate and protects the metal from corrosion. The function of the intermediate coat is to build up the thickness of the coating system, resist transport of aggressive ions from electrolyte to the metal substrate, and ensure good adhesion between the primer and the topcoat. The topcoat is exposed to the environment and must offer the metallic surface with the required colour, gloss, and resistance to ultraviolet radiation^[13]. Coatings can be classified into noble coatings and sacrificial coatings. Noble coatings provide barrier protection. Whereas in addition to barrier protection sacrificial coatings also provide cathodic protection. Coatings can be further classified into metallic, inorganic, and organic coatings.

- Metallic coating: metals or their alloys are applied to other metals via electroplating, hot dipping, thermal spraying, vapor deposition, etc can function as either noble coating or sacrificial coating.
- Inorganic coating: Non-metallic inorganic coating includes ceramic coating, cement, silicate, ceramics, conversion coating, and sol-gel coatings. The inorganic material in the sol- gel coating act as a good barrier against the diffusion of corrosive ions. Phosphate coating and chromate conversion coating are two usually used inorganic conversion coatings. Chromate conversion coatings (CCCs) are produced on the metal surface by chemical or electrochemical treatment of the metal or metallic coating in solutions containing Cr(VI) and other components. The porosity and stress-induced

cracking developed in inorganic coatings limit their use as efficient coatings as the corrosive species diffuse through the coating to the underlying metal^[14]

- Organic coating: Such as epoxy, plastics, enamel, oils, greases, and paints. In organic coatings, many different types of fillers and corrosive pigments are used, but the lack of thermal resistance, flexibility, and relatively less adhesion to metallic surfaces of organic coatings limit their long-term stability.
- Organic-inorganic hybrids (OIHs): OIHs offer an effective coating on the metal substrate by linking both inorganic and organic phases covalently on the molecular scale. In OIHs the capacity of inorganic phase to bond covalently with the metal increases leading to highly adherent coatings, which impedes the diffusion of aggressive ions from the electrolyte. The inorganic compound offer scratch resistance, durability, and adhesion to the metallic substrate. The organic part improves the flexibility and functional compatibility with the polymer system ^[15]. OIHs coating developed via the sol-gel process is considered as an effective alternative to CCCs for the metallic substrate.

References

- [1] A. Goyal, E. Ganjian, H. S. Pouya and M. Tyrer, *Construction and Building Materials* **2021**, *303*, 124461.
- [2] P. B. Raja and M. G. Sethuraman, *Materials letters* **2008**, *62*, 113-116.
- [3] J. M. Gaidis, *Cement and Concrete Composites* **2004**, *26*, 181-189.
- [4] a) V. S. Sastri, *Green corrosion inhibitors: theory and practice*, John Wiley & Sons, **2012**, p; b) A. Rostami, *SPE International Symposium on Oilfield Chemistry* **2009**.
- [5] E. Lyublinski, P. Lynch, I. Roytman and T. Yakubovskaya, *International Journal of Corrosion and Scale Inhibition* **2015**, *4*, 176-192.
- [6] S. T. M. TAKADA, H. GOTOU, K. MAWATARI, N. ISHIHARA and R. KAI, *Mitsubishi Heavy Industries Technical Review* **2009**, *46*, 43.
- [7] A. Leng and M. Stratmann, *Corrosion science* **1993**, *34*, 1657-1683.
- [8] E. Gutiérrez, J. A. Rodríguez, J. Cruz-Borbolla, J. G. Alvarado-Rodríguez and P. Thangarasu, *Corrosion Science* **2016**, *108*, 23-35.

- [9] a) Y. Qian, Y. Li, S. Jungwirth, N. Seely, Y. Fang and X. Shi, *Int. J. Electrochem. Sci* **2015**, *10*, 10756-10780; b) F. Presuel-Moreno, M. Jakab, N. Tailleart, M. Goldman and J. Scully, *Materials today* **2008**, *11*, 14-23.
- [10] a) M. Dabral, L. Francis and L. Scriven, *AIChE journal* **2002**, *48*, 25-37; b) E. Almeida, *Industrial & engineering chemistry research* **2001**, *40*, 3-14.
- [11] P. A. Sørensen, S. Kiil, K. Dam-Johansen and C. E. Weinell, *Journal of Coatings Technology and Research* **2009**, *6*, 135-176.
- [12] D. Kjærsmo, K. Kleven and J. Scheie, *Bording A/S, Copenhagen* **2003**.
- [13] a) R. Zhang, H. Chen, H. Cao, C. M. Huang, P. Mallon, Y. Li, Y. He, T. Sandreczki, Y. Jean and R. Suzuki, *Journal of Polymer Science Part B: Polymer Physics* **2001**, *39*, 2035-2047; b) J. Pospíšil and S. Nešpurek, *Progress in Polymer Science* **2000**, *25*, 1261-1335.
- [14] a) M. Norouzi and A. A. Garekani, *Ceramics International* **2014**, *40*, 2857-2861; b) J. Quinson, C. Chino, A. De Becdelievre, C. Guizard and M. Brunel, *Journal of materials science* **1996**, *31*, 5179-5184.
- [15] a) C. Jackson, B. Bauer, A. Nakatani and J. Barnes, *Chemistry of materials* **1996**, *8*, 727-733; b) T. L. Metroke, R. L. Parkhill and E. T. Knobbe, *Progress in Organic Coatings* **2001**, *41*, 233-238.
- [16] N. S. Sangaj and V. Malshe, *Progress in Organic coatings* **2004**, *50*, 28-39.

MULTICOMPONENT REACTIONS FOR THE SYNTHESIS OF COMPLEX MOLECULES

Dr. Jamsheena V.

Assistant Professor, PG Department of Chemistry,
KAHM Unity Women's College, Manjeri, Kerala- 672122, India
Email:jamshivkpt843@gmail.com

Organic synthesis is considered as a turning point of molecular science. Prof. K. C. Nicolaou from Rice University discussed the significance of organic synthesis in his several research articles. He stated in one of his research article "*One of the most vital and valued sub-disciplines of chemistry is the science of organic synthesis, without which much of science and industry would have remained paralyzed and sterile. This is the discipline that provides the myriad molecules from which emerge our most precious new material goods and gadgets, whether they are instruments to cure disease and promote wellness or tools that help us build machines, communicate, travel, and entertain ourselves, not to mention advance education and science, and achieve sustainability*". The development of sophisticated analytical and separation procedures necessitates the need for ideal synthesis. The target molecule should be assembled using easily available starting components in an easy, secure, cost-effective, and efficient process (Figure 1). In this context, multicomponent reactions (MCRs) satisfy majority of the criteria of ideal synthesis. MCRs are defined as reactions that involve three or more substrates and incorporate the majority of the substrate's atoms into the final product. Unlike multi-step total synthesis, MCRs produce the products in a single-pot operation with greater complexity and diversity (Figure 2). In MCRs, all the substrates react sequentially in a number of simple steps (the domino process) rather than all reacting at once to produce the final product.

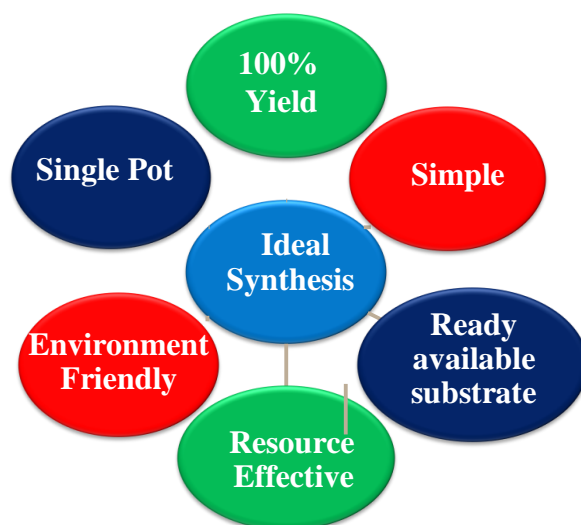


Figure 1. Criteria for ideal synthesis

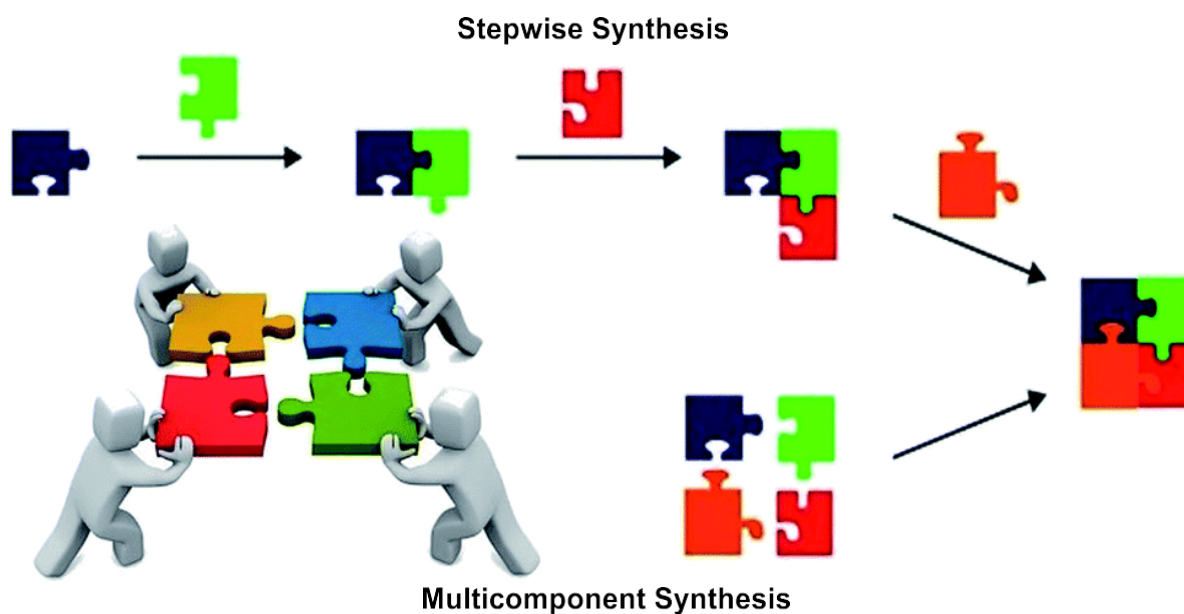


Figure 2. Stepwise linear synthesis vs multicomponent synthesis

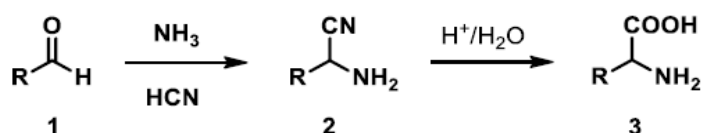
MCRs have so many advantages over conventional two-component reactions (2CRs) and multi-step total synthesis in contemporary organic synthesis.

2.1. Advantages of MCRs:

- Multiple new bond forms in a single-pot operation

- No alteration to the reaction conditions or isolation of intermediates.
- Atom, energy, time and economic efficient
- Exhibits extensive substrate scope
- Highly sustainable and convergent
- Complexity and diversity oriented synthesis

Strecker developed α -amino acid **3** synthesis in 1850 by condensation of aldehyde **1**, ammonia and hydrogen cyanide.⁶ The reaction proceeds via α -cyano amine intermediate **2** which upon hydrolysis generates α -amino acid **3** (**Scheme 1**). This reaction is considered as the first ever reported MCR. Twelve years ago, Gerhard and Laurent observed the formation of cyanohydrin imine as a poorly soluble compound from bitter almond oil and ammonia.



Scheme 1. Strecker synthesis of α -amino acid

APPLICATIONS OF MCRs

The easily automated one-pot MCRs have found applications in various fields. Especially, the isocyanide based MCRs (IMCRs) were well explored and being employed in drug discovery, natural products synthesis, diversity-oriented synthesis (DOS) and material applications.

MCRs in the synthesis of bioactive molecules

In the post-genomic era, medicinal chemistry added combinatorial synthesis and high-speed parallel synthesis in lead discovery and optimization in order to meet the vast need for diverse library of compounds by pharmaceutical industries. In this context, MCRs are considered as a powerful technology for the convergent synthesis of a diverse library of small molecule drugs. Utilizing MCR technology several protease inhibitors (e.g., serine, aspartyl, metallo and cysteine proteases), kinase inhibitors, phosphatase inhibitors, and G-protein coupled receptor ligands were synthesized (Figure 3).

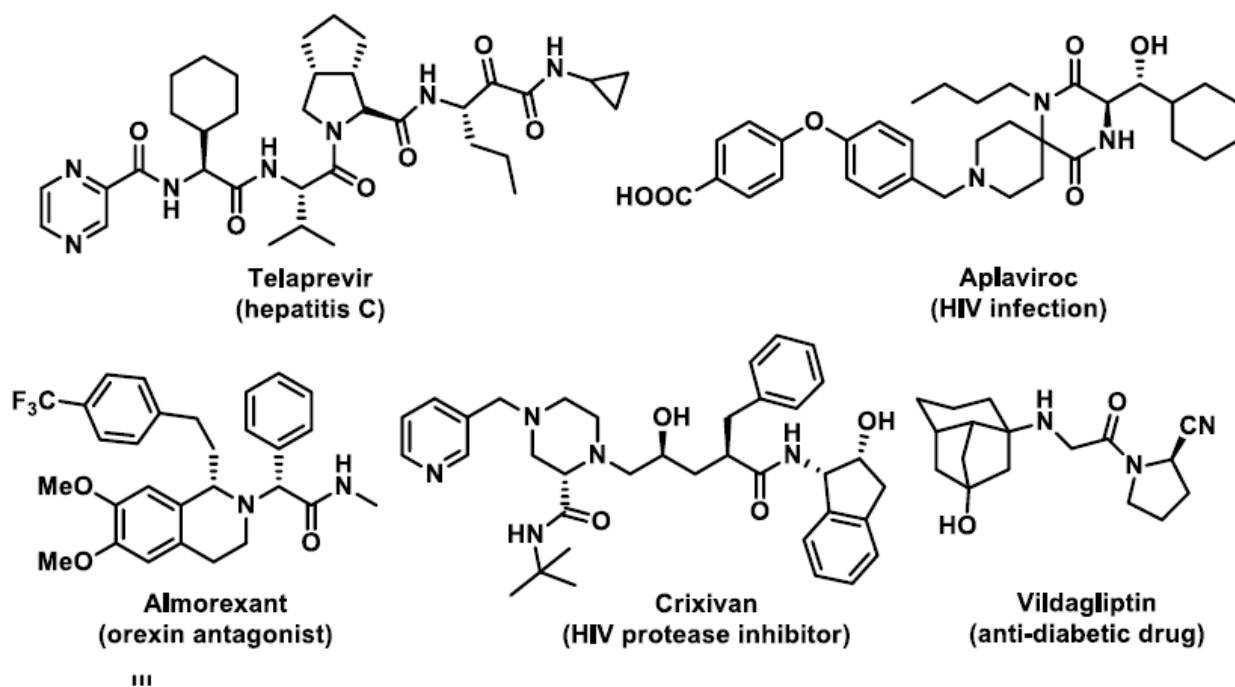
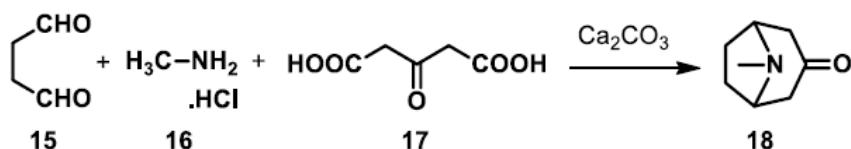


Figure 3. Selected examples of drugs synthesised through MCR

MCRs in synthesis of natural products

Initially, Robinson's synthesis of tropinone alkaloid by a double Mannich reaction (Scheme 2) laid the foundation for natural product synthesis using MCRs. Since then MCRs were underexploited in natural products synthesis for several decades, but recently MCRs experienced renaissance by the advent of combinatorial chemistry. Several complex natural products were synthesized by using MCRs as a key reaction strategy, and some of them are listed in the figure 4.



Scheme 2. Robinson's synthesis of tropinone by a double Mannich-3CR

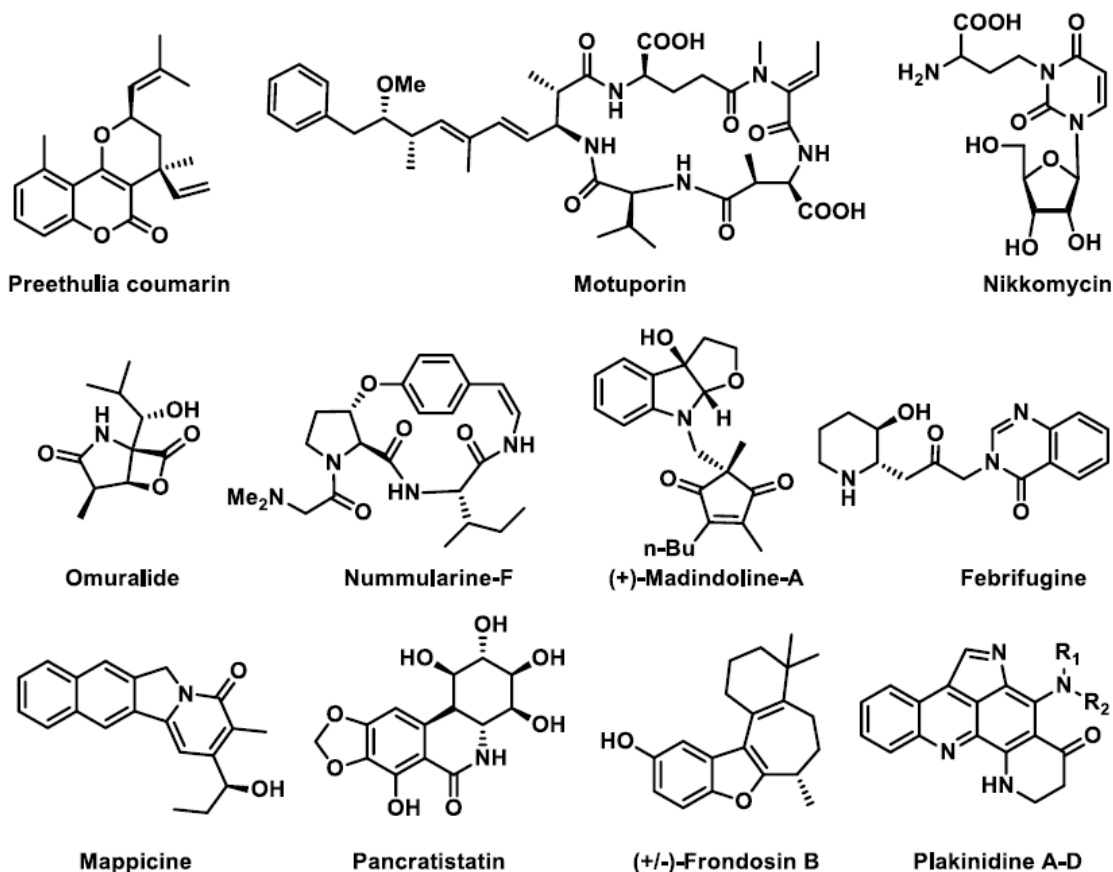


Figure 4. Targeted natural products using MCRs

MCR enable the facile, automated and high throughput generation of small organic molecules. The optimal MCR is sufficiently flexible that it can be employed to generate adducts bearing a variety of functional groups that may then be selectively paired to enable different cyclisation manifolds, thereby leading to diverse collection of products.

References

1. Nicolaou, K. C. *Angew. Chem., Int. Ed.* **2013**, *52*, 131.
2. Gaich, T.; Baran, P. S. *J. Org. Chem.* **2010**, *75*, 4657.
3. Wender, P. A. *Tetrahedron* **2013**, *69*, 7529.
4. Ugi, I.; Dömling, A.; Horl, W. *Endeavour* **1994**, *18*, 115.
5. (a) Brauch, S.; van Berkel, S. S.; Westermann, B. *Chem. Soc. Rev.* **2013**, *42*, 4948. (b) Armstrong, R. W.; Combs, A. P.; Tempest, P. A.; Brown, S. D.; Keating, T. A. *Acc. Chem. Res.* **1996**, *29*, 123. (c) Bienayme, H.; Hulme, C.; Oddon, G.; Schmitt, P. *Chem. - Eur. J.* **2000**, *6*, 3321. (d) de Graaff, C.; Ruijter,

- E.; Orru, R. V. A. *Chem. Soc. Rev.* **2012**, *41*, 3969. (e) Ruijter, E.; Scheffelaar, R.; Orru, R. V. A. *Angew. Chem., Int. Ed.* **2011**, *50*, 6234.
6. Strecker, A. *Ann. Chem.* **1850**, *75*, 27.
7. Laurent, A.; Gerhardt, C. F. *Ann. Chem. Phys.* **1838**, *66*, 281.
8. Weber, L. *Curr. Med. Chem.* **2002**, *9*, 2085.
9. (a) Domling, A.; Wang, W.; Wang, K. *Chem. Rev.* **2012**, *112*, 3083. (b) H. P. Isenring ; W. Hofhein; *Tetrahedron*, **1983**, *39*, 2591. (c) K. Rossen*, P.J. Pye*, L.M. DiMichelc, R.P. Volante and P.J. Reider, *Tetrahedron Letters*, **1998**, *39*, 6823-6826. (d) Marina Pedrola; Marta Jorba; Eda Jardas; Ferran Jordi; Ouldouz Ghashghaei; Miguel Viñas; Rodolfo Lavilla. *Front. Chem.* **2019**, *7*:475. (e) Lv, L.; Zheng, S.; Cai, X.; Chen, Z.; Zhu, Q.; Liu, S. *ACS Comb. Sci.* **2013**, *15*, 183–192. (f) Yihong Wan , Shengen Wu , Sichao Zheng, En Liang, Shuwen Liu, Xingang Yao, Qiuhua Zhu; *European Journal of Medicinal Chemistry* 200 (**2020**) 112318.
10. (a) Toure, B. B.; Hall, D. G. *Chem. Rev.* **2009**, *109*, 4439. (b) Hall, D. G.; Rybak, T.; Verdelet, T. *Acc. Chem. Res.* **2016**, *49*, 2489. (c) Gao, X.; Hall, D. G. *J. Am. Chem. Soc.* **2005**, *127*, 1628. (d) Penner, M. N.; Rauniyar, V.; Kaspar, L.; Hall, D. G. *J. Am. Chem. Soc.* **2009**, *131*, 14216. (e) Hashimoto, S.; Katoh, S.; Kato, T.; Urabe, D.; Inoue, M. *J. Am. Chem. Soc.* **2017**, *139*, 16420. (f) Tingting Cao, Lei Zhu, Yu Lan, Jun Huang*, Zhen Yang, *Org. Lett.* **2020**, *22*, 7, 2517.

SCAFFOLD DECORATED 1,2,3-TRIAZOLES AS POTENTIAL ANTI-CANCER AGENTS

Dr. Thasnim. P* and Dr. Rajeena Pathoor#

**PG Department of Chemistry, KAHM Unity Women's College, Manjeri,
Narukara (PO), Malappuram (Dt), Kerala, Pin: 676122*

E-mail: thasnim6390@gmail.com

*#PG and Research Department of Chemistry, Sir Syed College, Taliparamba,
Karimbam (PO), Kannur (Dt), Kerala, Pin: 670142*

E-mail: rajeenapathoor@gmail.com

ABSTRACT

1,2,3-triazole skeleton is a privileged building block for the discovery of new promising anticancer agents. Introduction of privileged scaffolds to the molecular framework of 1,2,3-triazole is an indispensable route to the wise exploitation of molecules with inherent potential for anticancer activities.

INTRODUCTION

About 13% of all human deaths throughout the world are caused by cancers, which are diseases characterized by uncontrolled cell growth, metastasis, and invasion. Although the risk of cancer increases with age, people of all ages even fetuses can be affected by the disease. Breast carcinoma (BC) is the commonest cancer among women and the second highest cause of cancer death. Most cases occur during age 45–55. It also occurs in men but is more than 100-fold less frequent than in women.

Chemotherapy is considered as the most effective method among many other methods prevalent to treat cancer. At present, the cancer treatment by chemotherapeutic agents, surgery and radiation have not been fully effective against the high incidence or low survival rate of most the cancers. Several nucleoside drugs have been developed as cancer treatment agents: cladribine, clofarabine, capecitabine, cytarabine, fludarabine, gemcitabine, decitabine, and floxuridine. The development of new therapeutic approach to breast cancer remains one of the most challenging areas in cancer research.

Cyclin-dependent kinases (CDK) are classic Ser/Thr kinases with molecular weights of 30–40 kDa. This family of enzymes plays an important and well-defined role in cell cycle regulation and proliferation. Abnormal activation of various CDKs can ultimately lead to deregulated cell cycle progression, a common feature in many cancers. Given the pivotal role that dysregulation of CDK activity plays in cancers, targeting the CDKs is a viable strategy for blocking and/or interfering with tumor cell proliferation. Thirteen CDK's and at least 29 cyclins have been discovered from the human genome and have been extensively characterized in regards to controlling cell cycle. Mutations in CDK proteins can result in the overexpression and altered function of CDK's and specific cyclins.

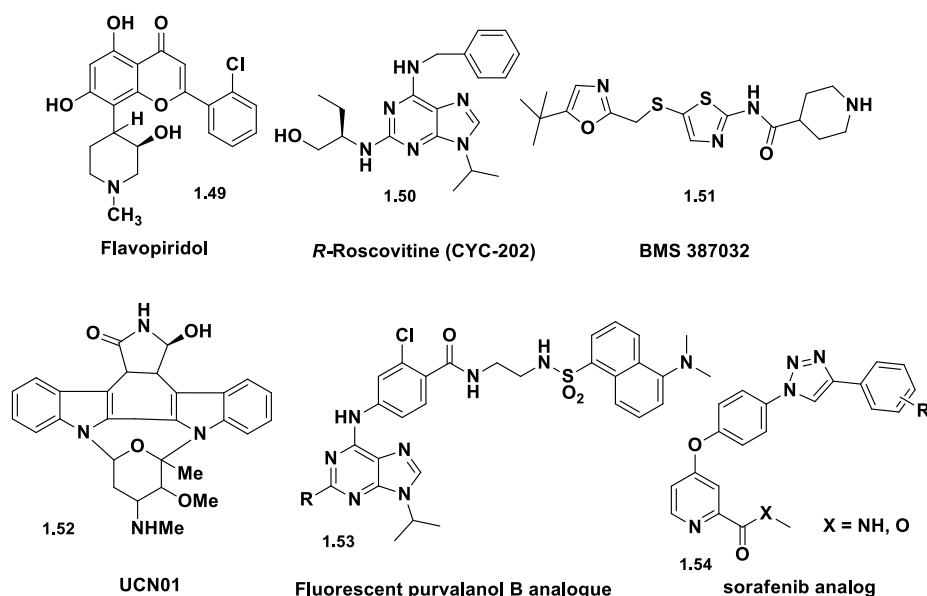


Figure 1. CDK inhibitors under clinical trials (1.49-1.52), an example for fluorescent CDK inhibitor (1.53) and a click derived CDK inhibitor (1.54)

Inhibitors of cyclin-dependent kinases (CDKs) are an emerging class of drugs for the treatment of breast cancers. Experimental evidence suggests that CDK inhibitors inhibit the cyclin D–dependent kinase activity and thus prevent tumor growth and/or at least partially revert the transformed phenotype. For example, reduction of cyclin D expression through antisense technology causes a concomitant decline in cyclin D–dependent kinase activity and results in inhibition of tumor growth, abolition of tumorigenicity, or, in some instances, tumor cell death. Several compounds are currently in clinical trials including flavopiridol (1.49), R-roscovitine (CYC202) (1.50), BMS-387032 (1.51), and UCN-01 (7-hydroxystaurosporine) (1.52). Most of these compounds, however, inhibit multiple CDKs, with CDK2 being a particularly common target in drug discovery programs because this enzyme is easily crystallized with inhibitors of varying molecular structure. CDK inhibitors are currently under evaluation in clinical trials as single agents and as

sensitizers in combination with radiation therapy and chemotherapies. Fluorescent CDK inhibitors (1.53) offer potential as novel theranostic agents, combining therapeutic and diagnostic properties in the same molecule. Development of click derived CDK inhibitors is an emerging field of drug discovery processes since they exhibit higher potency than other non-triazole inhibitors and several of them have been reported (1.54) (Figure 1).

TAILORING MOLECULES FOR BIOLOGICAL APPLICATIONS

Structural complexity and diversity of molecules are important criteria in drug discovery as well as material sciences. This fact led to the scientists to use the Diversity Oriented Synthesis (DOS) for the development of diverse structures for various applications especially in drug discovery. This concept was introduced by Schreiber in 2000, which involves the deliberate simultaneous and efficient synthesis of more than one target compound in a diversity-driven approach to answer a complex problem. Structural diversity can be achieved through the variation in various aspects like building blocks, stereochemistry, functional groups and most importantly the molecular frame work. Methods like Multicomponent reactions (MCRs) and introduction of privileged scaffolds are usually used to generate the structural diversity and complexity in molecules.

MCRs are one of the most important processes for the preparation of highly functionalized complex organic compounds in modern synthetic chemistry. They are special types of chemical transformations in which three or more starting materials react to form a product where the essential parts of the reactants must be seen in the newly formed product. The majority of MCRs are based on classical condensations between carbonyl derivatives and various nucleophiles, the illustrative example being the first known MCR, the Strecker synthesis of amino acids from aldehydes, potassium cyanide, and ammonium chloride reported in 1850. Others, like the Mannich reaction, and a host

of transformations designed for the synthesis of nitrogen-containing heterocycles including Biginelli, Hantzsch, or Asinger reactions, also rely on the classical condensation processes. The first example of MCR in natural product synthesis was reported in 1917 which is the Robinson synthesis of alkaloid tropinone.

Introduction of privileged scaffolds to the molecular frameworks is an indispensable route to the wise exploitation of molecules with inherent potential for biological as well as optical activities. The term ‘privileged structures’ was first described by Ben Evans of Merck research group during their work on benzodiazepines and has recently emerged as one of the guiding principles of modern drug discovery. Consequently, benzodiazepines were the first to be described as privileged. After this, many more privileged scaffolds were identified which include chalcone, benzopyrone, quinoline, isoquinoline, indole, pyrimidinone, oxazolones, β -lactams, tetracyclines, macrolides, coumarins, glycopeptides etc and recently macrocycles are also identified as privileged scaffolds. These scaffolds tend to impart highly favorable characteristics, while alterations to the secondary structure lead to high levels of potency and specificity. Using these scaffolds as a starting point, Nature has generated thousands of distinct molecules serving various purposes. Chemists have taken advantage of the principle of privileged scaffolds via isolation and synthesis of natural products as well as subsequent alteration to these scaffolds to introduce new analogs that possess improved activities.

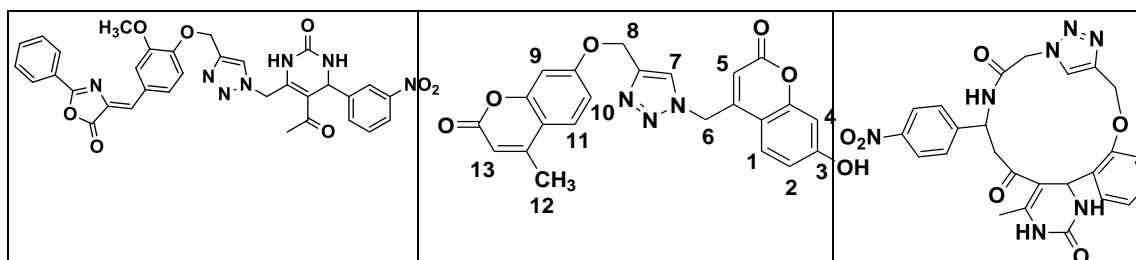


Figure 2. 1,2,3-triazole tailored with privileged scaffolds such as pyrimidinone, coumarin, oxazolones and macrocyclic variation of 1,2,3-triazole

Figure 2 shows such 1,2,3-triazole tailored with privileged scaffolds such as pyrimidinone, coumarin and oxazolones. The cytotoxicity evaluation results are promising and point to possibilities of these molecules as potential inhibitors of human breast cancer cell line MCF-7.

References

- (1) (a) For statistical information about cancer, see: World Health Organisation <http://www.who.int/mediacentre/factsheets/fs297/en/>; (b) Cancer Research UK <http://info.cancerresearchuk.org/cancerstats/incidence/age/>.
- (2) Ganesh, N. S.; Rahul, D.; Jyotsana, S.; Piush, S.; Sharma, K. K. *J Adv Pharm. Technol. Res.* **2010**, *1*, 109–126.
- (3) (a) Lauria, F.; Benfenati, D.; Raspadori, D.; Rondelli, D.; Zinzani, P. L.; Tura, S. *Leuk. Lymphoma.* **1993**, *11*, 399. (b) Pui, C. H.; Jeha, S.; Kirkpatrick, P. *Nat. Rev. Drug Disc.* **2005**, *4*, 369. (c) Bonate, P. L.; Arthaud, L.; Cantrell, W. R.; Stephenson, K.; Secrist, J. A.; Weitman, S. *Nat. Rev. Drug Disc.* **2006**, *5*, 855; (d) Issa, J.-P.; Kantarjian, H.; Kirkpatrick, P. *Nat. Rev. Drug Disc.* **2005**, *4*, 275. (e) Gore, S. D.; Jones, C.; Kirkpatrick, P. *Nat. Rev. Drug Disc.* **2006**, *5*, 891.
- (4) Yenugonda, V. M. *et al. Bioorg. Med. Chem.* **2011**, *19*, 2714–2725.
- (5) (a) Sherr, C. J. *Science.* **1996**, *274*, 1672. (b) Harper, J. W.; Elledge, S. J. *Curr. Opin. Genet. Dev.* **1996**, *6*, 56.
- (6) (a) Shapiro, G. I. *J. Clin. Oncol.* **2006**, *24*, 1770. (b) Vermeulen, K.; Van Bockstaele, D. R.; Berneman, Z. N. *Cell Prolif.* **2003**, *36*, 131. (c) Collins, I.; Garrett, M. D. *Curr. Opin. Pharmacol.* **2005**, *5*, 366.
- (7) Malumbres, M.; Barbacid, M. *Nat. Rev. Cancer.* **2009**, *9*, 153.
- (8) (a) Arber, N.; Doki, Y.; Han, E. K. *et al. Cancer Res.* **1997**, *57*, 1569–74. (b) Kornmann, M.; Arber, N.; Korc, M. *J. Clin. Invest.* **1998**, *101*, 344–52. (c) Sauter, E. R.; Nesbit, M.; Litwin, S.; Klein, S. A.; Cheffetz, S.; Herlyn, M. *Cancer Res.* **1999**, *59*, 4876–81.

- (9) Benson, C.; Kaye, S.; Workman, P.; Garrett, M.; Walton, M.; De Bono, J. *British Journal of Cancer*. **2005**, *92*, 7 – 12.
- (10) (a) Davies, T. G.; Pratt, D. J.; Endicott, J. A.; Johnson, L. N.; Noble, M. E. *Pharmacol Ther*. **2002**, *93*, 125–33. (b) Noble, M. E. M.; Endicott, J. A. *Pharmacol Ther*. **1999**, *82*, 269 –78.
- (11) Venkata, M. Y.; Tushar, B. D.; Scott, C. G.; Sivanesan, D.; Yonghong, Y.; Mikell, P.; Milton, L. B. *Bioorg. Med. Chem*. **2011**, *19*, 2714–2725.
- (12) Wenjing, Y.; Qi, Y.; Simiao, Y.; Ping, G.; Mingze, Q. *Molecules*, **2017**, *22*, 1759.
- (13) Ansgar, S.; Nathan, B.; Paul, S.; Peter, E.; Edgar, J.J. *Chem. Inf. Model*. **2006**, *46*, 525-535. (b) Jun-Seok, L.; Yun, K. K.; Marc, V.; Young-Tae, C. *Mol. Bio. Syst*. **2009**, *5*, 411–421.
- (14) Schreiber, S. L. *Science*, **2000**, *287*, 1964-1969.
- (15) Spring, D. R. *Org Biomol Chem*. **2003**, *1*, 3867-3870.
- (16) For reviews on MCRs, see: (a) Dömling, A.; Wang, W.; Wang, K. *Chem. Rev*. **2012**, *112*, 3083–3135. (b) Gulevich, V. A.; Zhdanko, G. A.; Romano, V. A. O.; Nenajdenko, G. V. *Chem. Rev*. **2010**, *110*, 5235–5331. (c) Corianda, U.; Felco, R.; Romano, V. A. O. *Chem. Soc. Rev*. **2012**, *41*, 3969–4009. (d) Rotstein, B. H.; Zaretsky, S.; Rai, V.; Yudin, A. K. *Chem. Rev*. **2014**, *114*, 8323–8359. (e) Strecker A. *Ann. Chem*. **1850**, *75*, 27–45.
- (17) (a) Mannich, C.; Krosche, W. *Arch. Pharm*. **1912**, *250*, 647–667. (b) Biginelli, P. *Ber. Dtsch. Chem. Ges*. **1891**, *24*, 1317-1319, 2962–2967. (c) Hantzsch, A. *Chem. Ber*. **1881**, *14*, 1637–1638. (d) Asinger, F. *Angew. Chem*. **1956**, *68*, 413.
- (18) Robinson, R. J. *Chem. Soc*. **1917**, *111*, 876-899.
- (19) Evans, B. E. *et al. J. Med. Chem*. **1988**, *31*, 2235-2246.
- (20) Fisher, J. F.; Mobashery, S. in *Privileged Scaffolds in Medicinal Chemistry: Design, Synthesis, Evaluation*, (Ed: S. Bräse), The Royal Society of Chemistry, Cambridge, UK 2015. 64. (b) Newman, D. J.; Cragg, G. M. *Future Med. Chem*. **2009**, *1*, 1415. (c) Jameel, E.; Umar, T.; Kumar, J.; Hoda, N. *Chem*.

- Biol. Drug Des.* **2016**, 87, 21. (d) Grover, J.; Jachak, S.M. *RSC Adv.* **2015**, 5, 38892. (e) Gaspar, A.; Matos, M. J.; Garrido, J.; Uriarte, E.; Borges, F. *Chem. Rev.* **2014**, 114, 4960-4992.
- (21) Richard S. B.; William, M. W. *Chem. Biol. Drug. Des.* **2017**, 89, 169–191.
- (22) Boettcher, T.; Pitscheider, M.; Sieber, S.A. *Angew. Chem. Int. Ed.* **2010**, 49, 2680.
- (23) Meryem Hrimla; Ali Oubella; Yassine Laamari; Lahoucine Bahsis; Adib Ghaleb; My Youssef Ait Itto; Aziz Auhmani; Hamid Morjani; Miguel Julve; Salah-Eddine Stiriba, *Biointerface Research in Applied Chemistry*, **2022**, 12, 7633 – 7667 and references therein.
- (24) (a) T. V. Soumya, P. Thasnim, D. Bahulayan, *Tetra. Lett.*, **2014**, 55. (b) Thasnim Puthiyedath; Damodaran Bahulayan, *Sensors & Actuators B Chemical*, **2017**, 239. (c) P. Thasnim, D. Bahulayan, *New Journal of Chemistry*, **2017**, 41. (d) Thasnim Puthiyedath; Damodaran Bahulayan, *Sensors & Actuators B Chemical*, **2018**, 272. (e) Thasnim Puthiyedath, Rajeena Pathoor, D. Bahulayan, *Tetra. Lett.*, **2019**, 60.

MESOPOROUS MATERIALS

Mrs. Najeera P C

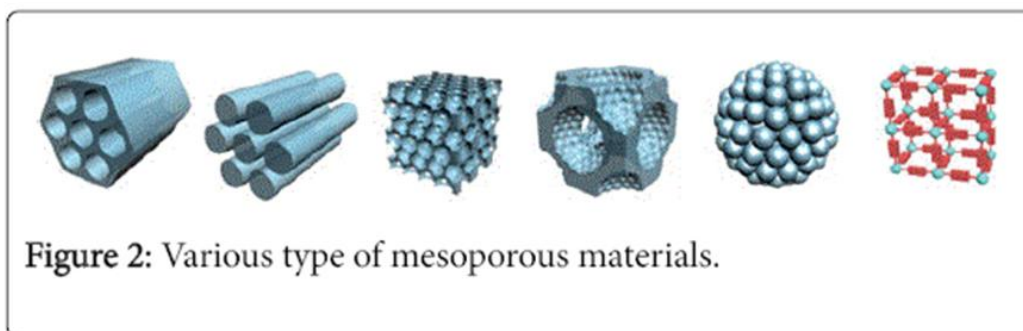
*Assistant Professor, PG Department of Chemistry, KAHM Unity Women's College,
Manjeri*

Kerala-676122,India

Email : najeerapc@gmail.com

INTRODUCTION

A mesoporous material is a nanoporous material containing pores with diameters between 2 and 50 nm. The development of mesoporous materials has offered great opportunities for new applications in a variety of fields, including heterogeneous catalysis, thanks to their special intrinsic structural features. In this article, we focus on the main achievements of mesoporous materials in both synthesis and catalysis fields. The development of synthesis strategies, especially designed for generating improved physicochemical and textural properties of mesoporous materials, which include silicas, metals, metal oxides, organosilicas, metal-organic frameworks, carbons and zeolites, is briefly summarized with special emphasis on mesoporous zeolites. Adsorbent mesoporous materials are highly efficient for the remediation of different compounds in environmental applications such as organic, inorganic, and gas molecules.



SYNTHESIS AND APPLICATION OF MESOPOROUS MATERIALS

There are many synthetic methods for mesoporous materials. They are hydrothermal synthesis, microwave synthesis, the sol–gel method, the phase conversion method, and the templating method.



CHARACTERIZATION OF MESOPOROUS MATERIALS

The arevarious instrumentation techniques that are used to investigate and characterize mesoporous materials in order to determine particle size, pore morphology, structure and surface information. The key biophysical techniques used to classify the most mesoporous materials are powder X-ray diffraction (XRD), transmission electron microscopy (TEM), scanning electron microscopy (SEM), energy dispersive X-rays are used to characterization techniques for mesoporous materials. Electron crystallography used for characterization.

APPLICATION OF MESOPOROUS MATERIALS

Mesoporous materials are perfect in diagnostics applications because of their enhanced image contrast and chemical stability. Currently the mesoporous materials have been envisaged for a variety of applications such as in energy conversion and storage, filtration, catalysis, optics, drug delivery and so on.

DRUG DELIVERY SYSTEM

The main challenge in the development of drug delivery systems (DDS) is that drug efficacy diminishes before reaching the target, primarily due to the excretion of the drug from the body. In addition, the drug carrier must be non-toxic and inert during the treatment period. Because most biological molecules and pharmaceuticals are on the order of a few nanometers, nanoporous silica with a pore size of 2 – 30 nm is of great relevance for such life science applications.

CATALYSIS

In catalysis, high surface area materials with nanoscale features are used to develop highly selective catalysts that reduce energy use and waste/pollutant generation in industrial applications. Porous materials, such as zeolites (microporous solids), are widely used in industry as catalysts and catalyst supports.

DIAGNOSTICS

Mesoporous materials are ideal in diagnostics applications due to their increased image contrast and chemical stability. Due to the low toxicity of silica based porous materials and their ability to host a variety of fluorescent markers, dyes and drugs can be used to track the location of therapeutic agents and their activity.

ADSORBENTS

Due to the high surface area of nanoporous materials allows their use as adsorbents for various gases, liquids, and toxic heavy metals. The uptake of these substances can be increased significantly based on the surface properties (hydrophobicity, hydrophilicity, or functionality), of the mesoporous silica materials. Several applications, such as removal of pollutants from water, storage, of gases (e.g., CO₂, H₂, O₂, CH₄, H₂S), adsorptive xylene separation, and separation of biological and pharmaceutical compounds, have been addressed through the use of mesoporous materials as adsorbents.

CHROMATOGRAPHY

The large pore volume, surface area, and narrow pore-size distribution of mesoporous silica, makes it a good candidate for size exclusion chromatography. These materials have been proposed as supports or stationary phases for size exclusion chromatography,

capillary gas chromatography, proteomics separations, normal phase High Pressure Liquid Chromatography (HPLC), as well as enantioselective HPLC.

Mesoporous materials have witnessed a great progress over the past decade. The potential applications of functional mesoporous materials in adsorption, diagnostic, catalysis, and biomedicine have also been discussed. That is very important to advance the chemistry, material science, biology, nanoscience and cross-over fields.

References

1. Wan Y, Zhao. 2007. On the Controllable Soft-Templating Approach to Mesoporous Silicates. *Chem. Rev.* 107(7):2821-2860.
2. 2008. Microporous framework solids. *Focus on Catalysts*. 2008(6):8.
3. Yaghi OM, Li G, Li H. 1995. Selective binding and removal of guests in a microporous metal-organic framework. *Nature*. 378(6558):703-706
4. Beck JS, Vartuli JC, Roth WJ, Leonowicz ME, Kresge CT, Schmitt KD, Chu CTW, Olson DH, Sheppard EW, McCullen SB, et al. 1992. A new family of mesoporous molecular sieves prepared with liquid crystal templates. *J. Am. Chem. Soc.* 114(27):10834-10843.
5. Doadrio JC, Sousa EMB, Izquierdo-Barba I, Doadrio AL, Perez-Pariente J, Vallet-Regí M. Functionalization of mesoporous materials with long alkyl chains as a strategy for controlling drug delivery pattern. *J. Mater. Chem.* 16(5):462-466.

NOVEL AREAS OF POLYMER RESEARCH

Dr. V.C Jasna *

*Assistant Professor, PG Department of Chemistry,
KAHM Unity Women's College, Manjeri, Kerala- 672122, India

Email id: jasnavc@gmail.com

The recent innovation in polymeric materials has driven social and physical development, polymers and their composites are the material's nerve centre for many practical applications. Some common applications of this new material are in the following fields automotive, sports, gadgets, aircraft, aviation, biomedical, nanotechnology, etc. Investigation of the surface properties of polymeric materials has become of great importance mainly because their interfacial interaction plays a very important role in the reliability of the underlying components. This unique problem requires a thorough investigation of all polymer-containing materials (whether natural or artificial) as one of their constituents. Examples include polymer composites, polymer biomaterials, multifunctional polymers, characteristic polymer materials, etc. Detailed investigation of these polymer materials with improved surface properties by improving physical properties or mechanical properties is rapidly increasing among researchers all over the world.

Polymers are used in a variety of technologies, from avionics to medical applications to pharmaceutical drug-delivery systems, biosensing devices, tissue engineering, cosmetics, etc. Because of their ease of manufacture, the use of polymers and their composites is increasing. When considering a polymer application, understanding its true value requires understanding how the material will perform over a long period of time. These materials can include natural fillers, polymers matrixes, foams, cement and composites, fillers, strands, films, layers, emulsions, coatings, Rubber, fasteners, glue resins, solvents, inks and paints, clothing, flooring, waste disposal Sacks and bundles of polymers. Automobile parts, windshields of military aircraft, pipes, tanks, pressing

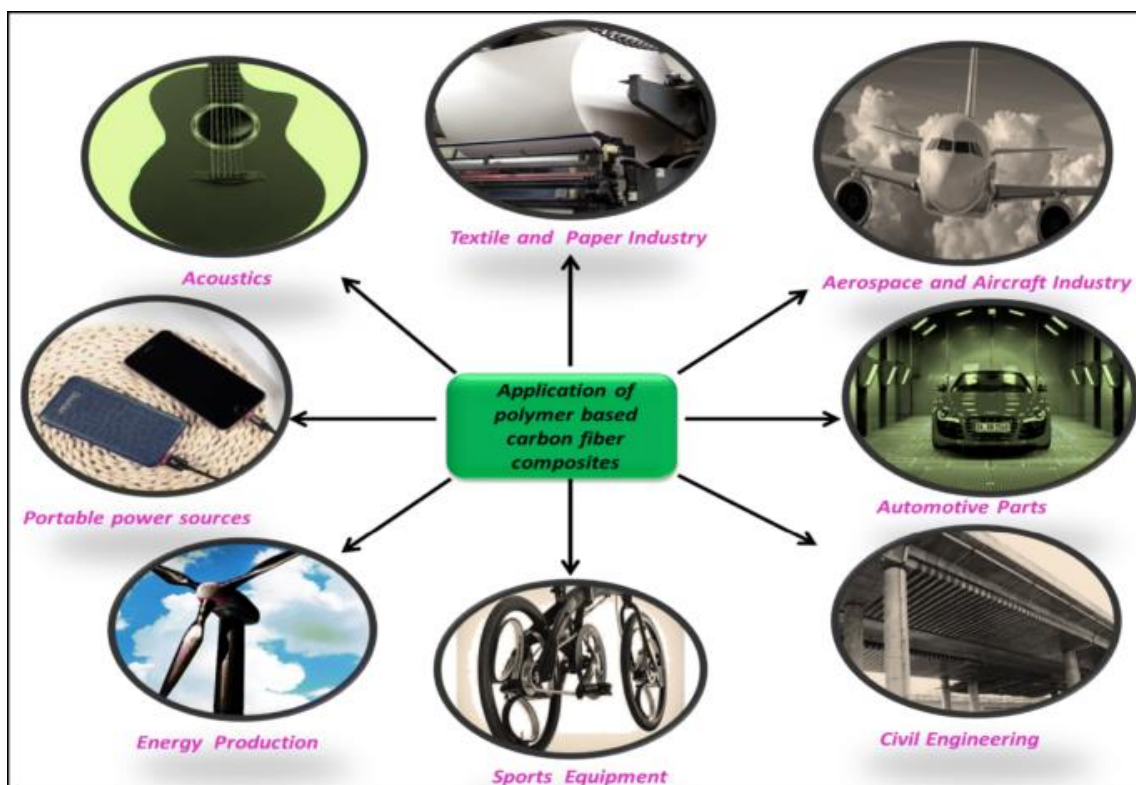
materials, protection, wood substitutes, cement, composite frames, and elastomers are some modern applications of today's polymers.

The use of natural fibers as reinforcing materials has been reported although it is possible to rediscover them on the technological track only recently dated back to the early 20th century. Currently seeks great importance to the task of enriching natural fibers in various biodegradable and non-biodegradable polymer matrices. Using natural fibers and fillers can be seen as a way of dealing with manufacturing issues and sustainable material systems for polymer composites. Using fibers from natural plant systems is a sustainable and economical option to enter the field of composite materials that are environmentally friendly, rich, and sustainable with a short throughput time and development cycle. With the continuous aggravation of environmental pollution and the continuous increase of garbage generation, there has been an increasing emphasis on developing new technologies using biodegradable reinforcement materials for the continuing needs of society. Among other natural fibers, naturally occurring cheap basalt fibers are made from crushed basalt and have the following unique properties: biodegradability, excellent key properties such as increased thermal stability, mechanical properties, etc. Basalt fiber-reinforced polymer composites have a wide range of applications in civil construction, automobile, aerospace, anti-radiation shielding, and other applications. Radioactivity through hazardous nuclear waste, insulation materials, etc. Basalt fibers also have sufficient capabilities to be recognized as a next-generation reinforcing material for structural applications, consumer applications, and mobility applications. Nanomaterial-reinforced polymer composites also play an important role in high-strength applications.

With the development of polymer technology, a new type of conductive polymers has emerged as potential materials for various charge transfer applications. The electronic conductivity of such polymers is tuned by doping and de-doping the materials. Recently, various conductive polymer composites have been successfully used as gas-sensing materials due to their unique electron-conducting properties and effective redox chemistry. The fabrication of composites of functional materials with conductive polymers improves the structural and physiochemical properties that always lead to high-performance gas sensors. They provide large surface areas for molecular interaction between the target gas and the sensing elements. They exploit the synergistic effect of the high affinity of polymers for redox reactions and the unique gas sensor properties of

inorganic functional materials. In general, semiconducting metal oxide materials are suitable fillers for the preparation of composites with conducting polymers. Commonly used conducting polymers are derivatives of polyaniline (PANI), polypyrrole, polythiophene, etc. The sensitivity and response time of these materials are important parameters for realizing a high-performance gas sensor. They are promising materials for improving the sensitivity, safety, and selectivity of sensors.

The development of comparatively stronger polymer composites, such as carbon fiber-reinforced polymers, has significantly improved material strength, chemical, and moisture resistance, durability, and interlaminar shear strength. Such reinforced material is widely used in the manufacture and development of multifunctional devices for aircraft, automobiles, biomedical, sensors, and other electronic applications. Machining of carbon filler reinforced polymer composites is significantly different from machining of metals due to plastic deformation, abrasive nature of reinforcement, and inhomogeneous structure. Generally, polymer composites are manufactured with a net shape, but custom machining processes are required for fitting and joining and final assembly.



The type, amount, and mixing technique of the filler contribute significantly to the performance of polymer composites in tribological systems. Due to their lighter weight and lower frictional properties, polymer composites are an important replacement for

metallic components used in bearings, housings, joints, etc. Polymer composites have very different friction and wear mechanisms compared to metals, mainly due to their softness, lower melting temperature, and lower overall thermal conductivity. The performance of tribological polymer composites also depends largely on the reinforcing materials, the type of fillers used, and the polymer matrices used in the composites. Various polymer composites made from polytetrafluoroethylene, high-density polyethylene, and polyethylene terephthalate have also been explored by various researchers for tribological applications.

Another major area of work is solid-state batteries, which are replacing liquid batteries due to safety considerations related to liquid electrolytes. The increasing demand for electric vehicles over the last decade has forced our society to respond by developing energy storage devices with high energy and power density and with high safety. Solid-state batteries use solid electrolytes, such as metal oxides, solid polymers, and so on. Polymer-based electrolytes have certain advantages over others, such as good flexibility, thermal stability, low flammability, high safety, and so on. However, their low mechanical strength, ion diffusion problems, and rapid decomposition are some of the major challenges. These challenges can be overcome by appropriate manufacturing processes, proper device design, and the use of hybrid materials. The emerging field of flexible electronics supports the use of polymer electrolytes in portable and flexible devices. The commonly used polymer electrolytes are based on poly(acrylonitrile), poly(acrylonitrile-co-butadiene), poly(ethylene oxide), polyvinyl alcohol (PVA), poly(ether acrylate), etc. This monograph contains a collection of application aspects of natural and synthetic polymers. It is expected that this monograph can provide a consolidated overview of the current state of the art in polymer applications.

References

1. Khandelwal, S. and Rhee, K. Y., "Recent advances in basalt-fiber-reinforced composites: Tailoring the fiber-matrix interface," *Compos. B, Eng.* **192**, 108011 (2020).
2. Kumar, S., Mer, K. K., Gangil, B., and Patel, V. K., "Synergy of rice-husk filler on physico-mechanical and tribological properties of hybrid Bauhinia-vahlia/sisal

- fiber reinforced epoxy composites,” *J. Mater. Res. Technol.* **8**(2), 2070–2082 (2019a).
3. M. H., Gurudatt, N. G., and Shim, Y. B., “Applications of conducting polymer composites to electrochemical sensors: A review,” *Applied Materials Today* **9**, 419–433 (2017)
 4. Sundriyal, P., Sahu, M., Prakash, O., and Bhattacharya, S., “Long-term surface modification of PEEK polymer using plasma and PEG silane treatment,” *Surf. Interfaces* **25**, 101253 (2021).
 5. V. C. Jasna, T. Anilkumar, Adarsh Ajith Naik and M.T. Ramesan* “Novel Nanocomposites based on Chlorinated Styrene Butadiene Rubber and Manganous Tungstate: Focus on Curing, Mechanical, Electrical and Solvent Transport Properties” *Journal of Materials Science* 53(13):9861-9876 (July 2018).
 6. Tushar Kanti Das, Prosenjit Ghosh & Narayan Ch. Das “Preparation, development, outcomes, and application versatility of carbon fiber-based polymer composites: a review” *Advanced Composites and Hybrid Materials* **volume 2**, pages214–233 (2019)
 7. Patel, V. K., Kant, R., Chauhan, P. S., and Bhattacharya, S., “Introduction to applications of polymers and polymer composites,” in *Trends in Applications of Polymers and Polymer Composites*, edited by V. K. Patel, R. Kant, P. S. Chauhan, and S. Bhattacharya (AIP Publishing, Melville, New York, 2022), pp. 1-1–1-6.
 8. K. Friedrich “Polymer composites for tribological applications” *Advanced Industrial and Engineering Polymer Research*, 1, 3-39 (2018).

STRONG LIGHT-MATTER COUPLING TO MODIFY CHEMICAL AND PHOTO-PHYSICAL PROPERTIES

Muhammed Abdul Hakkeem C

K.A.H.M. Unity Women's College, Manjeri, Kerala-676122, India

Mail id: hakeemchatholi@gmail.com

INTRODUCTION

Electromagnetic field can interact with molecular systems by the exchange of photons. If the molecular transition energy is equal to the energy of incident radiation, the photon will be absorbed by the molecule. This is an example of weak light-matter coupling. If the molecule is placed inside an optical cavity, the interaction leads to strong coupling. Optical cavity is an arrangement of mirrors in which standing waves of light can be formed. Standing waves in the cavity are known as cavity modes (Figure 1). To form standing wave for a particular frequency, twice the separation between plane mirrors must be equal to an integral multiple of wavelength. The separation between mirrors can be adjusted to form cavity modes for a particular frequency. In order to have strong coupling, the cavity mode must be in resonance with molecular excitation. Here, two attempts to verify the effects of strong light-matter coupling on chemical and physical properties are reviewed.

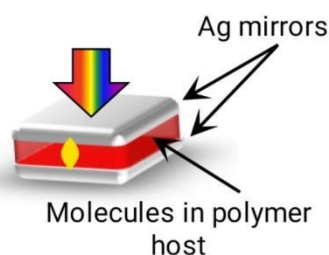


Figure 1. An optical cavity formed by two Ag mirrors with molecules in polymer host

RABI SPLITTING

If a molecule is embedded in an optical cavity and the cavity mode is in resonance with molecular excitation, strong light-matter coupling occurs. The cavity mode and the molecule forms a coupled system in which the energy oscillates between the quantum systems as in the case of two simple harmonic oscillators coupled together. As a result of strong light-matter coupling, molecular energy levels are modified, leading to the formation of hybridized molecular photonic states known as polaritons. The excited molecular energy levels split into two polaritonic states – upper polariton and lower polariton (Figure 2). The energy difference between upper polariton and lower polariton is Rabi splitting. The coupled system can be thought of as a single entity with new energy levels and must have distinct chemical and physical properties.

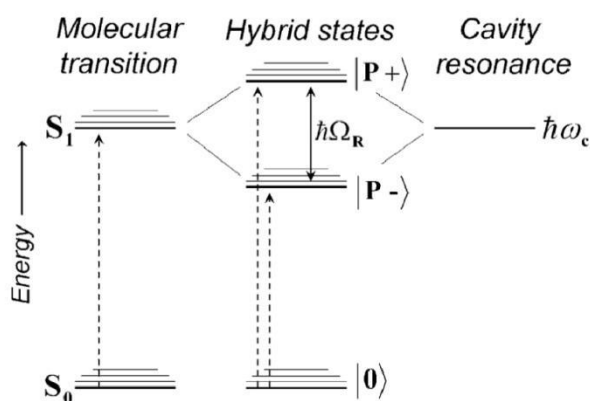


Figure 2. Simplified energy landscape showing the interaction of a HOMO–LUMO (S_0 – S_1) transition of a molecule resonant with a cavity mode¹

STRONG COUPLING WITH VACUUM CAVITY MODES

The Rabi Splitting energy of a molecule embedded in a resonant optical cavity is given by

$$\hbar\Omega_R = 2Ed \sqrt{n_{ph} + 1} = 2d \sqrt{\frac{\hbar\omega}{2\varepsilon_0 V}} \sqrt{n_{ph} + 1}$$

Where $\hbar\omega$ is the energy of cavity mode which is equal to molecular transition energy, V is the mode volume ie, the volume occupied by the cavity mode, d is the transition dipole moment and n_{ph} is the number of photons inside the optical cavity.

Even if the number of photons in the cavity is equal to zero, there remains a finite Rabi Splitting due to strong coupling with vacuum electromagnetic field or vacuum cavity modes. The vacuum mode should be in resonance with molecular excitation.

MODIFICATION IN CHEMICAL REACTIONS

The effects of strong coupling of a molecular system with vacuum field on chemical reaction were verified by James A Hutchison and team in 2012¹. They studied the photo isomerisation reaction of Spiropyran into Merocyanine, when the sample was embedded in a resonant cavity. The Spiropyran undergoes a bond cleavage following a photo excitation by UV light of wavelength around 330nm.

The Spiropyran in polymer host PMMA (Poly Methylmethacrylate) was embedded between two Ag mirrors insulated by PVA (Poly Vinyl alcohol) as shown in figure 3(d). Absorption spectra and reaction rate were studied with and without strong coupling with resonant optical cavity. Without coupling, Spiropyran and Merocyanine have absorption peaks at 330nm and 560nm respectively (Figure 3(c)). The cavity was adjusted to be in resonance with 560nm. Then, under strong coupling, Merocyanine shows two peaks at around 500nm and 650nm. The splitting of absorption (Figure 3(f)) into two new peaks is due to the strong coupling with cavity modes and the resulting formation of hybrid states. The spectrum of the coupled molecule is independent of the light intensity or no. Of photons which indicate that the coupling is with vacuum field.

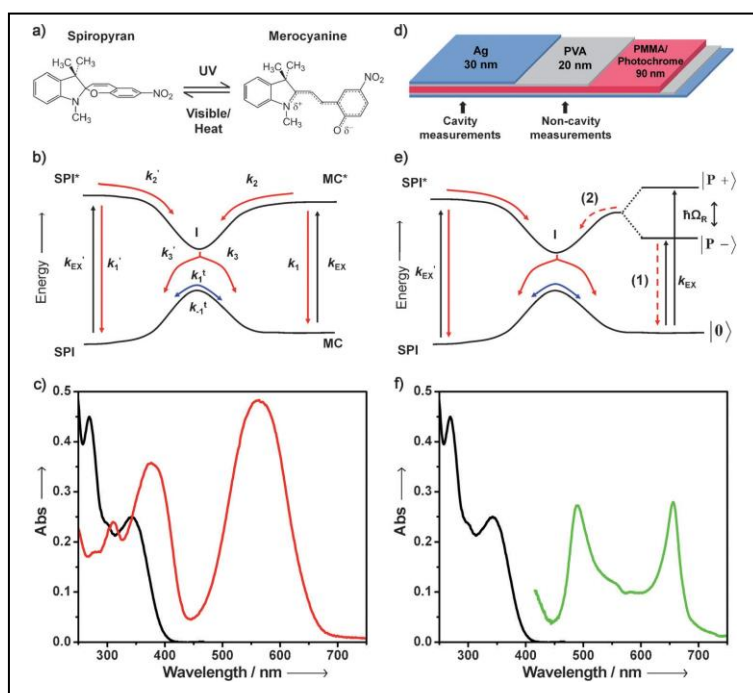


Figure 3. The molecular structure, cavity structure, energy landscapes and absorption spectra of Spiropyran and Merocyanine

The energy landscapes of the molecule Merocyanine was modified as shown in figure 3(e). This modification will definitely modify the photo isomerisation reaction rate. The scientists measured the transmission amplitude of photo excitation radiation, from which the absorption amplitude was calculated. The value of absorption points towards the reaction rate and formation of Merocyanine. It was found that absorption was reduced due to Rabi Splitting. The observed photo isomerisation reaction rate was slowed down significantly in the cavity structure due to the modification of reaction potential by strong coupling with vacuum cavity modes. Thus, modification in molecular energy landscapes modifies the reaction rate and yield.

Strong coupling can either speed up or slow down a reaction depending on the reorganization specific energy levels. The coupling can be done to a specific vibration transition to modify the reactivity of a bond. Since the formation of hybrid states changes the energy levels at play, it will in principle modify the ionization potential and the electron affinity of the system. The work function of coupled material will be modified and measurements to verify this are under way. Fine tuning the work function by strong coupling to vacuum field could have significant consequences for device design and performance¹.

COLLECTIVE RAYLEIGH SCATTERING

The Rabi Splitting of energy levels of molecular system embedded in an optical cavity in the absence of photons is given by

$$\Omega_R = \frac{2d}{\hbar} \sqrt{\frac{\hbar\omega}{2\varepsilon_0 V}} N$$

Where, N is the number of molecules in the system. The \sqrt{N} dependence indicates collective interaction between molecules and optical modes.

Adina Golombek, M Balasubrahmaniyam and team in 2020 studied the Rayleigh scattering from dye molecules in a polymer host under resonant and non-resonant conditions with vacuum cavity fields. They observed strong resonant Rayleigh scattering under strong coupling². The Eigen states of the coupled system are delocalized across a macroscopically large ensemble of molecules. The molecules in the resonant cavity are coupled together by means of cavity modes and acquire distinct physical properties.

CONCLUSION

Strongly coupling with a vacuum optical cavity i.e., by embedding the system between two plane mirrors finely tuned to be in resonance with molecular excitation, the reaction rates and yields can be controlled. Moreover, it was recently verified experimentally that the polaritonic states exhibit strong resonant Rayleigh scattering under strong coupling with vacuum cavity modes, and it indicates the modification in photo physical properties of materials also.

References

1. Modifying Chemical Landscapes by Coupling to Vacuum Fields. By James A. Hutchison, Tal Schwartz, Cyriaque Genet, Eloise Devaux, and Thomas W. Ebbesen. *Angew. Chem. Int. Ed.* 2012, 51, 1592–1596
2. Collective Rayleigh scattering from Molecular Ensembles under Strong Coupling. By Adina Golombek, Mukundakumar Balasubrahmaniyam, Maria Kaeek, Keren Hadar, and Tal Schwartz. *J. Phys. Chem. Lett.* 2020, 11, 3803–3808
3. Molecular polaritons for controlling chemistry with quantum optics. By Felipe Herrera and Jeffrey Owrutsky. *J. Chem. Phys.* 152, 100902 (2020); <https://doi.org/10.1063/1.5136320>