SDC EC India Decennial Celebration

Colours in our Life: From Aesthetics to Functions

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Louis Pasteur said "Luck favours the alert mind." The French chemist and microbiologist famously created a vaccine for chicken cholera by accident. Similarly, Smith and Subramanian, as it turns out, stumbled upon an undiscovered pigment of blue — the first new blue in over 200 years.

SDC EC India organized its 10th Anniversary on 28th July 2016 at Mumbai Cricket Association Indoor Cricket Academy & Recreation Centre Boundary Room, attended by Trustees (founder, past and present), Medalists, Sponsors, Members, invitees and resource persons of seminars, workshops and jury. Special Guest Prof G.D.Yadav, Vice Chancellor of ICT graced the occasion. Mr.V.R.Sai Ganesh, Secretary anchored the proceedings.

Overview: Dr.(Mrs.) Ela Dedhia, Chair person welcomed the audience and gave glimpses of the eventful journey of SDC EC recapitulating international/national conferences, seminars, lectures, panel discussions, workshops (practical hands on experience in coloration), Young Talent Search and Fashion Design (national students' competition) with research tempo in the youth. Winners of the national heat participated in international competitions held in UK, China etc. The emphasis has been on ecological regulations, sustainable coloration, innovations and issues of environmental pollution, water and energy. Industry sponsors supported their activities.

The Mumbai Chapter is a registered educational charity and is known as "The Society of The Dyers and Colourists Education Charity". It was approved by the SDC UK Council on 6th September 2000 and became a registered charity in the year 2006. It catered to the needs of stakeholders and industry personnel, faculty and students. Besides cloth sector, they wish to be more efficient and effective in exploring coloration of other articles in the industry spheres of colour.

Felicitations of Medalists and Qualification (2016): Qualification ***CCol ASDC***: Mr.Andrew Filarowski, Technical Director of SDC UK) bestowed the awards and Certificates to Mr.Ambadas and Mr.Dipak Sangware.

Gold Medal: Experts were identified, recognized and encouraged through Medals (Gold, Silver and Bronze) and Certificates by SDC UK, which was handed over at the hands of Dr.Sivaram. Mr.Dilip Raghavan introduced Dr.P.R.Roy, revered as 'Father of Denim' in India who was bestowed with Gold Medal for distinguished service to the textile industry. A PhD in textiles from University of Manchester and with 40 years in industry, research and teaching, he is Chairman of Diagonal Consulting (India) and spearheaded the development of indigo, wool and silk was instrumental in identification and setting up businesses in association with McKenzie USA. He took up the challenge of formulating, negotiating and finalizing strategic alliances with leading American and European textile companies.

Bronze Medal: Mr.Kiran Prayagi received Bronze Medal for sustained contribution to coloration and printed packaging industry. He obtained Diploma from Government Institute of Printing Technology, Mumbai and proceeded to London College of Printing on British Council Scholarship and studied colour management, measurement, photography marketing, etc and attended training of manufacturers in printing and graphic art industry. He has participated in print and related competitions besides speaking in national and international printing conferences. For over 24 years he has been running technical and

management consultancy for the printing and graphic arts industry and 160 organisations in India and overseas have taken the advantage of his services.

Chief Guest **Padma Shri Dr.S.Sivaram** is presently INSA senior scientist at NCL, Pune, CSIR Bhatnagar Fellow and J.C.Bose Fellow and former director of NCL. He is Alumnus of Madras Christian College and obtained PhD in chemistry in 1971 under the supervision of Nobel Laureate Prof H.C.Brown, Purdue University and DSc in 2010. He has several awards to his credit and varied research interests that include polymer synthesis and structure-property relationship. He has guided 36 students for PhD besides 12 Post Doctoral fellows with 210 papers in peer reviewed scientific journals. He holds 49 EU and US and 52 Indian patents and licensed to companies worldwide. Besides lecturing around the world, he has been a visiting professor at various reputed universities. President of India conferred prestigious civilian honour Padma Shri in 2006.

Keynote address on **"Colours in our Life: From Aesthetics to Functions"** Definition of colour according to Long (2011) is the object appearance, distinct form, shape, size or gloss that depends on spectral composition of incidental light, the special reflectance or transmission of the object and the special response of the observer as well as illuminating and viewing geometry. Colours are dyes for different sectors of applications. Molecules provide colours and aesthetics. Therefore feel, texture and function are important. There are molecules that are colourful and products in the market place, which use them and never see them. This is an area, which is immensely growing in the world, chemistry is common and people who are familiar with classical dyes are comfortable with this kind of molecules and they have to be understood in the context of their functions and hence from aesthetics to functions. We are looking at colours with advanced materials, which provide certain function. As a family of materials, chemistry is becoming invisible and because of its invisibility, people do not understand that there is so much chemistry. Perhaps this may be one of the reasons why people do not appreciate chemistry any more compared to the past. This is another dimension to functional aspects of chemistry rather than physical or looks of the aesthetics.

Colours have fascinated human being from time immemorial. What is Colour? How do we explain Colour? Democritus (around 500 BC), Pliny the Elder organised the knowledge in the form of writing in 11 volumes though people were using colours before 1000 BC. The cave paintings of Ajanta used colours (refined pigments water soluble based on kaolin, lamp black, glauconite: green ochre: yellow and lapis lazuli (blue) about 200 BC. The blue colour has been troublesome for humanity for a long time though it is used in mobile phone screens and display systems it does not have a molecule that gives blue colour. In organic light emitting diodes, red and green exist. Organic light emitting materials are 24 times more energy efficient than conventional lighting. With R, G and B, white light can be made. Blue was Ultramarine blue. The shades of blue are difficult colours and quest for blue continued. The brightest blue colour that appeared in the literature commercially entered the market 3 months ago, published and patented 4 years ago.

Isaac Newton demonstrated fundamental aspect of understanding that colour originates when light interacts with matter. Colour is not intrinsic property of any material but interaction of light with matter. Colour has no physical significance and perception arises out of light, material and human brain. Combination of these 3 components is called colour. Yet blue has been a question as to why in the ocean blue, sky blue and water colourless. Scientific under standing of colour, scattering of light

and ability of matter to scatter light gives colour to many things was contributed by 3 physicists, Raleigh, Einstein and C.V.Raman. Nitrogen, oxygen and carbon dioxide in the air were responsible for scattering of light and that caused colour. Origins of colour in precious stones e.g. cut diamond in different angles exhibit different colours. When light interacts with matter, various types of phenomena occur and one of them is scattering phenomena that leads to colour in materials.

· ***Chemical industry***: Colours began the chemical industry. The first factory in the world that produced a chemical in a commercial reactor for which a manufacturing plant was set up to make synthetic indigo and that was BASF in1897. Adolf von Bayer synthesised this interesting molecule in 1905 and won the Nobel Prize as natural indigo was not available in Europe. The Bengal connection - indigo began in 1777 in India and in 1914, India was exporting 20,000 tons to Europe and that triggered the commencement of chemical industry in Europe and for organised chemical industry in Western Europe. In 1857, Bengal plantation workers who were producing indigo stopped producing in protest against the treatment meted out to them. Indigo is one of the blue colours for denim. Blue in arts is fascinating than any other. Ultramarine blue (1480) is Bellini shade; Prussian blue for the soldiers in Prussia. Van Gogh substituted Cobalt blue in 1890.

· ***Colour psychology***: Pablo Picasso said colours like features follow the changes of emotions and stated that when he was sad, he used blue. Essential objects are light, object and observer. Since there is an observer who is sensing colour, people say colour is moody. It is brain that perceives colour and in response to other stimulus in the brain and therefore colour leads to moods (happy, sad etc).

· ***Expanding world of colour applications***: Colour is not limited to texture, perception or décor and this is where conventional application of colour comes in. Textiles, surface coatings, food and pharma, display and lighting system, energy harvesting devices, printing inks, biomedical and imaging applications, surface protection, OLED materials, light absorption, inkjet laser etc. Food and pharmaceutical industry evolved into a field to the consumer, lot of colour went into this area with business prospects.

· ***Functional applications of colour***: Display systems like mobile phone, television (colour comes from organic molecules). Harvesting devices - solar cells exploit ability of molecule to absorb. Printing inks with colour is a huge area and imaging applications in biomedical sciences. Light and human tissues are seen by imaging techniques which require high performing colouring materials. Display and lighting system, energy harvesting devices, printing inks and biomedical and imaging applications are functional materials though they are nothing but dyes and colours. Industry is moving from one part of domain of application to the other with more value addition. There could be a lot of similarities, techniques and methods currently used with existing materials that you could extend to new materials. These are the businesses in the future to give us the kind of returns we need to survive.

· ***Dyes & Colours***: Industry is fragmented, R&D intensive, raw material availability and environmental issues. It is a $4-bn (2012) business expected to double by 2020. We are predominantly textile colours (60%) and it is important to look beyond textiles. Reactive dyes export is 60%, Organic colours 13% and Optical brighteners 13%. Export is in low priced commodity products. We do not export anything which is worthwhile and technology intensive products and much of it comes from other parts of the world e.g. Merck, Germany. Lot of organic synthetic chemistry is done in India but the finished products are coming from elsewhere. Much of the colours businesses are important businesses and one needs to look at from this place to where do we move ahead in terms of new opportunities? One must focus on R&D and in this industry such intensity is extremely low (0.1% of 6) and Merck is at 7-10% on sales in terms of making molecules.

· ***Organic colours***: Carotenoids at $1.5-bn globally with huge emerging market, part of it is synthetic, fermentation and natural.

Interaction of light with matter is a profound concept in science. Colours in the material world are both nature made and manmade, exquisite manifestation of the science, have an ability to

create energy out of light and also exploit same phenomenon. Therefore if you want to take light energy and convert into electrical energy, you have to embark on the same phenomenon and the same types of molecules. What are the opportunities that are opening up today?

· ***Dye Sensitised Solar Cells***: Molecules which are part of solar cell and use a dye which is a chemical. DSSC can deliver 12% efficiency in converting light to electricity whereas Silicon gives 20% efficiency. It consists of a dye, titanium nano particles and electrolyte which are put in some form and start generating electricity from solar energy. When this journey began about 20 years ago and the concept looked at, people were extracting 1% of energy from light and today they are able to extract 14%. Molecules are natural dyes, industrial dyes, phthalocyanine dyes, porphyrin dyes, metal complex dyes and Ruthenium dyes. These dyes (yellow, orange, green) are understood in terms of absorption properties and how they function in this application. They do not require sunlight and can harvest electricity from diffused light in day time or diffused light. Whatever light available can be converted back into electricity. Essentially you are taking stray light whether natural or artificial and reconverting back into electricity. You are using electricity to energise light, convert it back into electricity using this technique. It is an amazing application and makes sense in terms of energy efficiency. This uses electricity and the same light can be converted back into electricity. Many of the applications are indoor applications and for outdoor applications, silicon is preferred.

In Australia, there is Building Integrated Photovoltaic (BIPV) and these are embedded into the architecture e.g. part of window or glaze partition in home or office and they will be continuously extracting energy out of that and whole lot of power within the building in order to manage your IOT like sensors, detectors etc. These can be made flexible, wearable (on hand), paintable so that room décor matches with the décor of this device and can also harvest diffused light and convert into electricity, which is a biggest advantage. Variety of applications e.g. Sony night lamp powers all devices besides seeing, it also harvests energy. You are able to power every device including ear phone.

· ***Organic solar cells***: Dye molecules are used e.g. Squaraine dyes. One can get 4 or 5% efficiency with these devices. Mechanism and device architecture were not dealt with owing to complexity. Organic photovoltaic are flexible materials and can produce 11.5% efficiency. They are layers of organic chemical materials, dyes multilayer assembly and print using inkjet printing. Make ink out of chemicals and the emerging technology can print on a film, which can harvest electricity from any light. This is roll to roll printing, which is continuous printing line. In the current printing technology, you can use ink formulated with these chemicals/dyes and print it on a surface and it can provide the kind of device that will harvest energy forward light. The molecules are not complex and can easily be made and these are emerging technologies, but the challenge is in getting printing done. There are only few companies which can do printing efficiently like Konarka Technologies (USA) and HelioTec SunBed (Germany) and Solamer (UK) set up for continuous printing lines, which can print polyester film with these inks. There are a couple of companies one in Manipal and the other in Gurgaon which are trying to start printing. These are low intensity in terms of energy and volumes of manufacturing and amenable scales to bring the cost down. These are continuous processes and one can bring scales of high values depending upon the markets.

· ***Diketo-Pyrrolo Pyrrole*** dyes discovered by CIBA in 1970s for variety of applications and Pyrrolo Pyrrole modified cyanine dyes are used in imaging techniques. The family of dyes are near Infra Red absorbing dyes (700-900 nm), which are used in vivo imaging of cells. Therefore look at diagnostics, disease mechanisms and understanding what is happening at cellular level using these dyes which have negatively fluoresce under those conditions. This dye can be irradiated with a laser of 825 nm, it gives emission of 840 nm. This can be used for effecting abnormality of cells. The area of imaging in biomedical devices is an important area of technology coming out of a classical dye DPP and developing new applications of imaging are on the anvil.

· ***New Blue Pigment after 200 years***: It is inorganic bright blue pigment basically make up of Yttrium. Indium and Manganese oxide This bluest

blue (YInMn blue) or MAS Blue was developed by M.A.S.Subramaniam and co-workers (JACS 131, 17084, 2009). Commercial manufacturing has begun in America. Cobalt blue (Cobalt is toxic), Prussian blue (hydrolytically unstable releases hydrogen cyanide) and Ultramarine blue (not stable in acids at high temperatures) this blue is stable in acid and at 800°C. Innovation and Science never ends and keeps going. In organic molecules, one can get best red and green and not blue. If best blue is available, one can get white light and with that one can replace Gallium Nitride LEDs. One can get Yellow light and not white light and for that bright blue is needed.

· ***How does nature create the colours***? Nature produces colours with ease and how can we get inspiration from nature to produce next generation of texturing surfaces that produce colours? A butterfly does not have any wind mills, or dyeing or colorants. It is colourless and transparent and yet it produces colour. It is something you perceive though it is not there. Essentially it is with a colour that is produced by certain physical structuring of surfaces and nothing to do with chemicals. Therefore if you know how to physically structure surfaces, then you can produce colours. The frontiers are moving to see how to create surface textures that will produce in a transparent material the colours that you need or want and that is the ultimate destination.

Dr.Sivaram concluded that colour is a metaphysical question and not a chemical or material or light and it is something else and that is what one needs to look at if you want to create the future of colour.

Proposing **Vote of Thanks**, Mr.Sai Ganesh offered special thanks to the Padma Shri Dr.S.Sivaram, Mr.Andrew Filarowski, Awardees, Trustees, invitees, members and office staff for making the celebration a success. The celebration ended with cutting a cake followed by dinner.

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In the coming months, the 'AVA cleanphos' process will be tested at a pilot scale at AVA Green Chemistry Development GmbH in Karlsruhe. According to AVA-C02, the process has the potential to be more efficient and cost-effective than existing phos- phorus recovery methods, as municipal sewage sludge is converted first into HTC-coal before the phosphate is isolated. This creates two commercially interesting products - a valuable fertiliser and phosphorus-free HTC-coal. In the future, CO_2-neutral HTC-coal could be used as a direct substitute for lignite, which would lead to substantial CO_2 emission reductions, it added.

AIR PRODUCTS OPENS NEW HYDRO EN PLANT IN CANADA

US-based Air Products and its sub-sidiary, Air Products Canada Ltd., recently dedicated its new world-scale hydrogen production facility in Fort Saskatchewan, near Edmonton (Alberta, Canada). The facility produces over 150 million standard cubic feet per day (mmscfd) of hydrogen and is connected to Air Products' existing hydrogen pipeline network, which supplies refiners, upgraders, chemical processors and other industries in the Alberta region. The new plant, as well as Air Products two existing hydrogen production facilities located near Edmonton, are joined via a 30-mile pipeline network to provide a very reliable source of hydrogen for these industries.

Hydrogen is widely used in petroleum refining processes to remove impurities in crude oil, such as sulphur, olefins and aromatics, to meet fuel specifications. Removing these components allows gasoline and diesel to bum cleaner and thus makes hydrogen a critical component in the production of cleaner fuels needed by modem, efficient internal combustion engines.

Pipelines offer a safe, robust and reliable supply of hydrogen to the refinery and petrochemical industry around - the world. Besides the hydrogen pipeline system in Alberta, Air Products also has a hydrogen pipeline in Samia (Ontario, Canada) and operates the world's largest hydrogen pipeline network in the US Gulf Coast, as well as pipeline systems in California, in the US and Rotterdam, in the Netherlands.