GREEN CHEMISTRY: ADVANCEMENTS AND OBSTACLES IN RELATED TECHNIQUES

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ABSTRACT

Though we are all aware of green chemistry as an attribute to the different synthetic techniques and processes, yet we need to bring in more of refinement into this attribute to make it more sustainable and meaningful. Here an attempt is made to review these aspects from the basic level to the latest advancements based on microwave assisted synthesis, sonolysis, metathesis, and other synthetic processes that mean to be termed as environmental friendly. Certain illustrations and references are further made to facilitate the awareness on these advancements and limitations.

KEY WORDS: Green chemistry, microwave assisted synthesis, sonolysis, metathesis

INTRODUCTION

There are a number of techniques or approaches which can be attributed to green Chemistry especially based on the synthetic approaches. The content presented here puts forward certain recent advancements in green chemistry and also the challenges these techniques or approaches need to overcome to term them as complete green chemistry related ones. The latest techniques that are much abundantly used are based on Microwave synthetic approaches and Sonochemistry. While in the former case, frequencies range between 300 MHz and 300 GHz, the later deals with region between 20 kHz and 1 MHz. The successfulness and sustainability is established already by the synthesis of certain important substances. Yet there are certain things to be yet proven and established considering their complete description and nature as green chemistry.

Microwave assisted reactions are considered "cleaner". They last only very few minutes, produce minimum waste and result in high yield. This technique is now-a-days used in various aspects like drug discovery, employing ionic solvents. Latest microwave synthesizer is pictorially illustrated below with a special reflux condensers and digital indicators.

Figure.1. Latest microwave synthesizer with a special reflux condensers and digital indicators

Though there are vast number of articles published over the past 25 years that describe this non-conventional heating technology as being 'green' or environmentally friendly, the justification based on energy efficiency is still questionable because typically only 50 per cent of the electrical energy used is converted into microwave energy and also not all microwaves generated will be absorbed by the reaction mass particularly for small samples compared to larger ones. Hence small-scale synthetic preparations are found to be particularly inefficient based on this principle of energy efficiency.

Sonochemistry is where irradiation with high intensity sound or ultrasound, acoustic cavitation is done. It offers the potential for shorter reaction cycles, cheaper reagents, and less extreme physical conditions with complete mass transfer. Advancements in sonochemistry using organic solutions are much considerable due to its safer solvent method. Much is researched now upon its use in nanomaterial synthesis as varied characteristics are exhibited in that level. For instance, in the degradation of organic pollutants, ultrasound based synthesized nanocatalyst function more actively and the same can also be applied to drug delivery systems and tumor treatment. This is in contradiction to nanosized ones which usually are not environmental friendly on that scale.

Now-a-days metathesis is also prominently researched after the year 2005 when it was recognized with the Nobel Prize. Metathesis is a catalytic chemical process that uses significantly less energy and has the potential to reduce greenhouse gas emissions for many key processes. The process is stable at normal temperatures and pressures, can be used in combination with greener solvents, and is likely to produce less hazardous waste.

Elevance Renewable Sciences used the concept of metathesis to break down natural oils and recombine the fragments into high-performance chemicals for which it even won the Presidential Green Chemistry Challenge Award in 2012.

Over the recent past a number of other research works being carried can be treated as trend setters if put into a complete engineered product. For instance Charles E. Wyman et al claim to have developed a versatile, relatively non-toxic, and efficient method called Co-solvent Enhanced Lignocellulose Fractionation (CELF) way to convert raw agricultural and forestry residues

and other plant matter, known as lignocellulose biomass, into biofuels and chemicals. If it can be really materialized into large scale production, the products can be end up with drop-in fuels.

Virginia P. Silva Nykanen et al developed an efficient and stable star-shaped plasticizer for starch called cyclic phosphazene with hydrogen bonding aminoethoxy ethanol side chains.

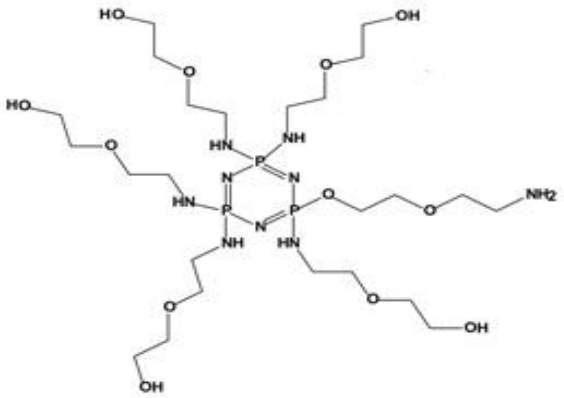

Figure.2.Molecular structure of Cyclic phosphagene

Based on this they transformed rice starch into a temporally stable, optically transparent, biodegradable plastic with a high degree of mechanical strength and good thermal resistance.

Another remarkable and astonishing claim is by Bert Hamelers etal in ACS' newly launched journal Environmental Science & Technology Letters, describing a technology that would react the CO_2 with water or other liquids and with further processing, produce a flow of electrons that make up electric current. Thus a new method for producing electricity from carbon dioxide is put forward and if can be materialized can do wonders related to the environment.

Renewable energy technology, that is also an emerging green chemistry aspect, is focusing more on wave energy, plant based biofuels and solar power. Sum Tze Chien et al claim to have made advancements in Perovskite-based solar cells. They are considered a remarkable next generation solar cell material made from organic-inorganic hybrid that can convert up to 15-20 per cent of sunlight to electricity almost as that of the current solar cells. However little is known on why or how it has that much of the characteristics.

When doped with nickel, strontium zirconate perovskite catalyst, produced by a low temperature hydrothermal route, can act as efficient catalyst for reforming methane rich biogas with minimal carbon deposition. This provides a potentially very attractive and sustainable source of useful chemicals from biogas.

On similar lines to explain the effective non-toxic catalytic activity, the production of aliphatic thermoplastic polyurethanes using tin-free catalysts especially Fe(III) based substances like Ferric chloride is also developed replacing the earlier much used organo tin compounds which release the harmful tin into the atmosphere.

Artificial leaves are now developed that can mimic photosynthesis when covered with water and placed in sunlight splitting hydrogen and water. This hydrogen as a fuel or combining it with CO_2 can further produce fuels like methanol. An artificial leaf design by Danial Nocera from MIT replacing costly platinum with a cheap nickel-molybdenum-zinc compound can be considered as a source of an inexpensive and a compact source of renewable energy.

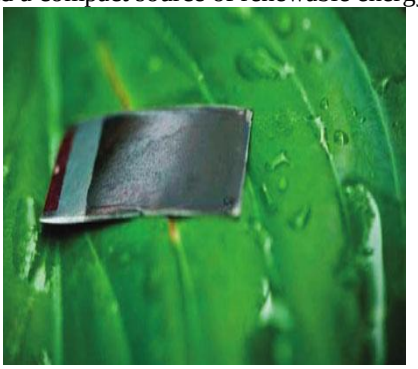

Figure.3.Artificial leaf; Courtesy: ACS

Reports have been given about developing a new device to reduce particle emissions for small-scale wood burning based on an electro filter system tested in 2006.

Many researchers are working upon latest green technologies like Green Concrete, Underwater Kites, Bamboo Laptops, etc. These have their own accomplishments to make but on the whole be treated as advancements in the field of green chemistry/technology.

Many countries promote green investment as another innovative approach to deal with air quality and environmental problems by providing tax compensation that would improve the rate of return. Environmentally friendly projects that qualify for green financing include sustainably built apartments, windmills and bio-agricultural companies and even nature and forest projects.

CONCLUSION

Whatever be the developments in the field of material science and its applications they should bind over to the principles of green chemistry to be sustainable, reliable and everlasting. Not only do these advancements indicate the development factor but also guide us towards more responsibilities to make this environment safer. Unknowingly we may be incorporating materials into the environment that are less scrutinized and lead us to problems that may require greater environmental solutions.

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