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A STUDY ON APPLICATION OF NANOCATALYSIS AS BURGEONING REMEDY FOR IMPROVEMENT OF AIR QUALITY INDEX IN INDIAN METROPOLITANS: A CHALLENGE

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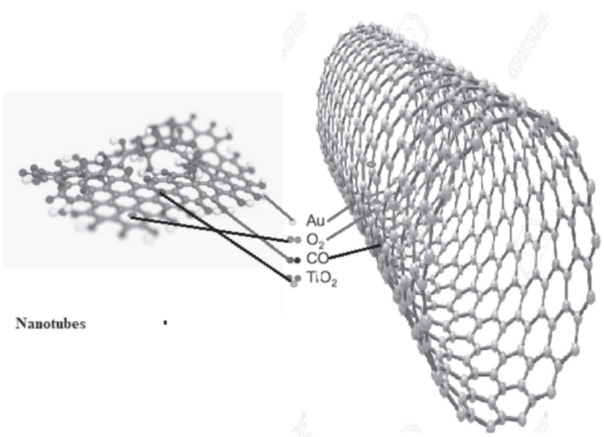
ABSTRACT

Continuous monitoring of Air Quality Index (AQI), by Central Pollution Control Board (CPCB) in Indian metropolitan cities is quite alarming. At local level, how nanocatalysis (Au, TiO_2 nanoparticles) can be used as air pollution remedy is a challenging task as it itself can pose health risk hazards. The study throws light on nanotechnology applications and it's controlled monitoring.

KEY WORDS : AQI, CPCB, nanoadsorbents



INTRODUCTION

Various types of pollutants are emitted from industrial processes or human activities, such as carbon monoxide (CO), chlorofluorocarbons (CFCs), heavy metals (arsenic, chromium, lead, cadmium, mercury and zinc),hydrocarbons, nitrogen oxides, organic compounds, sulfur dioxide and particulates in the atmosphere. This is because of lowering of absorption capacity of these pollutants in considerable amount because cutting down of trees. The following case studies shown below are taken from CPCB.

Case Study

Depending upon the data taken from CPCB, Air Quality Index (AQI) as per latest 28-11-2019, in two densely populated Capital cities (Delhi and Lucknow) in India has been shown in these Figures (1 and 2)

The harmful effects of air pollution can produce serious hazards. According to CPCB, the extent of hazard can be seen in this Figure 3.

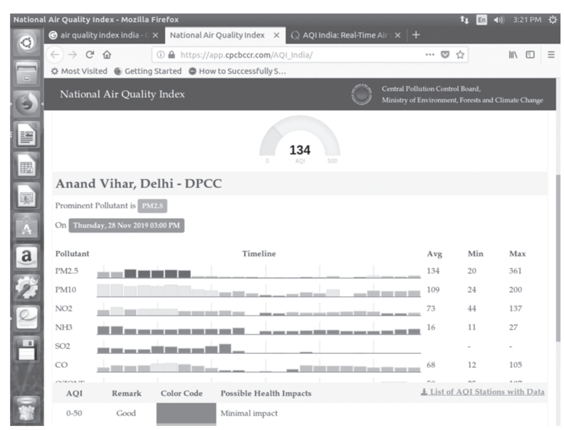


Fig. 1. AQI Delhi

AQI can be improved with the help of nanotechnology. Most of the greenhouse gases have permanent negative effect on atmosphere because of

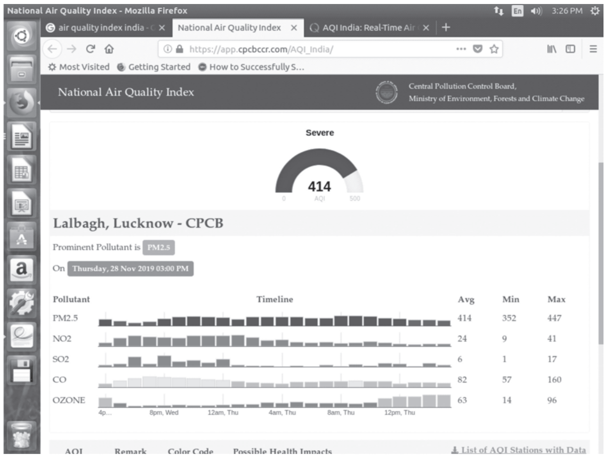


Fig. 2. AQI Lucknow

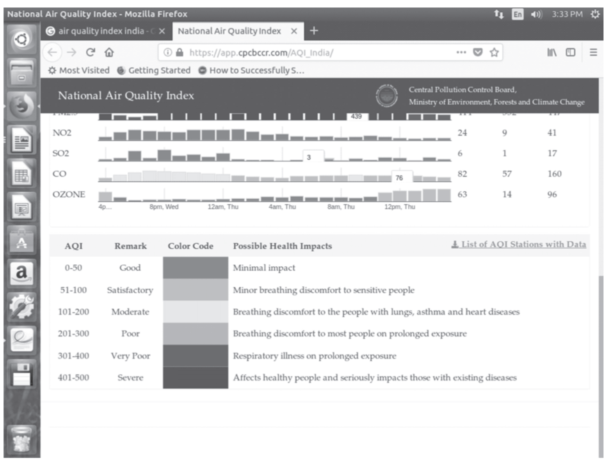


Fig. 3. Hazards of Air Pollution/smog (CPCB)

their capability to remain in the climate for many years. Air contaminants can be treated by various methods using adsorbent nanomaterials (Wang *et al.*, 2013; Bergmann *et al.*, 2015). But, how this can be accomplished has to be discussed.

DISCUSSION

Nanoadsorbents structure have properties of interacting with organic compounds via noncovalent forces such as hydrogen bonding, electrostatic forces, ð-ð and hydrophobic interactions, and van der Waals forces (Ren *et al.*, 2011). At the surface of Carbon nanotubes (CNTs) structure, combination of one or more surface functional groups (OH, COOH, C=O) can be made very effectively, which may increase the selectivity and the stability and influences the maximum adsorption capacity (Gupta and Saleh, 2013).

The active surface of nanoadsorbant is considered to be very efficient in catalytic properties. As the catalyst's size is decreased, its active surface area increases leading to the increase in the reaction efficiency. Catalysts currently in use include a nanofiber catalyst made of manganese oxide that removes volatile organic compounds from industrial smokestacks (Ren *et al.*, 2011 and Ozkar, 2009). Other methods are still in development as given in Fig. 4 (Saito *et al.*, 2017).

The use of TiO2 (Low *et al.*, 2017), MnO_2 nanofibres have a synergetic effect on nanofibres thereby making them a very efficient class of nanofibre composites.

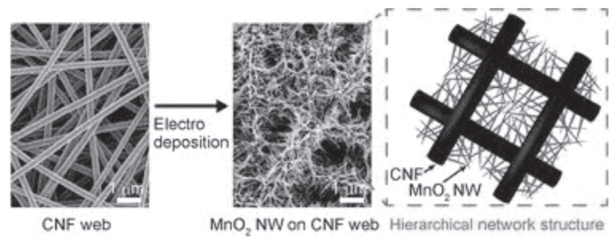


Fig. 4. Manganese oxide nanofibres

Future Applications

However their local applications to improve AQI of Indian Metropolitan cities, limiting the emission of greenhouse gases and converting them into renewable energy resources, is under continous research. The conversion of carbon dioxide and water into fuels for solar refinery has been a potential solution for decreasing greenhouse gas emissions. Zeolites have high CO_2 absorption capacity but only at ambient temperatures. They are not very effective at very high temperatures. However, these zeolites can be converted into derivative compounds as "Organometallic Frameworks" , e.g. zeolitic imidazole frameworks (ZIFs), where metal atoms are linked by ditopic imidazolate $(C_3N_2H_3^-)_{10}$, are excellent adsorbents for CO_2 with high capacity and selectivity and are used in fuel gases.

"Carbonate looping" is a cost effective, and advantageous method for CO_2 capture. It has been demonstrated using CaO, which is surplus in nature. But, this method has very low stability.

$$CaO + CO_2 \rightarrow CaCO_3; \Delta H = -179 \text{ kJ/mol}$$

"Anionic Clays" known has Hydrotalcites having molecular stoichiometry $M^{2+}{1-x} M^{3+}_x (OH)_2 A^{m-}_{x/m} \bullet yH_2O$, where M^{2+} is typically Mg^{2+}, Zn^{2+}, or Ni^{2+}; M^{3+} is typically Al^{3+}, Ga^{3+}, Fe^{3+}, or Mn^{3+}; and A^{m-} includes CO_3^{2-}, Cl^-, SO_4^{2-}, NO_3^- absorb CO_2 at basic surface sites but capacity is too low (Jeffery *et al.*, 2014).

Challenges and Limitations

Recent researches show, a lot of risk factors using nanoadsorbants as air pollution remedy. It may lead to the release of air-borne particles in the environment. Estimating their risks in the environment requires an understanding of their mobility in the environment, availability and distribution in food chain, which may adversely affect ecosystem and produce health hazards. For example:

Nano Silver: Broad spectrum biocide.

Concerns: Ends up in soil and water bodies in ionic form, toxic to aquatic life.

Titanium Oxide: absorb ultraviolet rays & reflects most of the sunrays at the nanoscale

Concerns– produce'free radicals'in the presence of light that are highly reactive and shown to damage DNA and cause cell toxicity

To ensure that nanoscale materials are manufactured and used in a manner that protects against human health and environmental risks.

Various countries like China, Japan, Egypt are upto safety measures owing to the risk of nanoparticulates. But the Indian picture is of much concern.

Table 1. Treatment techniques used to eliminate and monitor the emission of the greenhouse gases and other air pollutants by different nanoadsorptive materials with citations

Nanoadsorptive materials	Types of nanoparticles	Target pollutant gases	Removal mechanism	References
Carbon nanotubes (CNTs)	(SWNTs and MWNTs)	NOx (mixture of NO and NO_2)	NO and O_2 pass through CNTs and NO is oxidized to NO_2 and then adsorbed on the surface of nitrate species.	(Long and Yang, 2001; Zhang *et al.*, 2012)
	CNTs-APTS), Modified CNTs using 3aminopropyltri-ethoxysilane (APTS).	CO_2	Surface of CNTs with abundant amine groups that provide numerous chemical sites for CO_2 adsorption which makes CNTs adsorb more CO_2 gases at low temperature range (20-100 °C).	(Su et al., 2009)
	SWNTs/NaClO	Isopropyl vapor	Physical adsorption by Vander Waals forces and chemical adsorption onto adsorbent surface functional groups.	(Hsu and Lu, 2007)
	CNTs deposited on quartz filters	VOCs	It carriedout by π–π interactions	(Amade *et al.*, 2014)
	Si-dopedand Boron-doped	CO and CH_3 OH gases.	Physisorption or chemisor ption, electronic properties of SWCNTs improves significantly the adsorption of gases	(Azama *et al.*, 2017)
Fullerene	fullerene B_{40}	CO_2	High adsorption capacity	(Dong et al., 2015)
Graphene	Grapheneoxide (GO)/ nanocomposites	CO_2, NH_3, SO_2 H_2S and N_2	Functional groups on GO have high adsorbing power.	(Petit and Bandosz, 2009; Seredych and Bandosz, 2012)

- Funding process is primarily restricted to upstream research
- Although, DST (Department of Science and Technology) has supported and funded risk research, however, its mandate does not primarily include risk governance
- Major risk related areas come under the responsibility of Ministry of Environment and Forests (MOEF), none of the acts and legislation of MOEF has explicitly identified nanoparticles as a hazard
- Concerns regarding risk are not high on agenda in India

CONCLUSION

Keeping in mind the nano health- hazards, it is important to orient research in relation to environmental pollution control issues by nanotechnology. Nanocatalysts for sustainable air purification are mostly still under development or just at the start of being ready for practical use.

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