A Review- Green chemistry approaches in hazardous gases

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Abstract
Gases are very important for survival. In Air there are many different types of hazardous gases are present. They very harmful to all. Green chemistry provides systematic way to control on hazardous gases environmental peace. Green chemistry is useful in how to eliminate or control on hazardous gases. Many company use many harmful chemical formulate often release dangerous volatile organic compounds like Nitrogen oxide, sulfur oxide, carbon dioxide, etc. they decrease air quality it cause3 climate change and then green chemistry help to reappear to prevent pollution before it happen.
***Keywords**: Green chemistry, Green solvent, catalysis, prevension, less hazardous chemical synthesis, safer solvents and Auxiliaries, design for energy efficiency of hazardous gases.*

Introduction-

Gases play important role for survival. Gases is homologous fluid generally of low viscosity. It has no definite volume but assume the volume of any vessels which it is placed. Specific laws that express the behavior of gases at various temperature and pressure are very important in petroleum technology.

Gases contain oxygen, co2, nitrogen, etc. It contain oxygen that living beings needs to breath. It contain carbon dioxide that plants need for photosynthesis. It plays important role in water cycle, etc. So that, it is very useful to all of us But in Industry and all over the world hazardous gases are formed. It has dangerous volatile organic compounds, carbon dioxide, sulfur dioxide, Nitrogen dioxide, etc. To prevent pollution before it happens.

Industrial chemical manufacturing faces severe environment and safety challenges due to the generation, handling, and emission of toxic and hazardous gases, including phosgene, carbon monoxide, chlorine, hydrogen cynide, sulfur dioxide, and nitrogen oxides. This research paper evaluates the application of the 12 principles of Green Chemistry to mitigate gas-phase toxicity across chemical syntheses and industrial emission. We analyze three primary strategic pathways.

Key principle targeting hazardous emission-

1.PREVENSION-

Designing synthetic processes so that toxic gases are never created avoiding the needs for expensive gas scrubbers on filters.

2.LESS HAZARDOUS CHEMICAL SYNTHESIS-

Replacing toxic reagents with benign alternative that do not off gas dangerous vapour during reaction.

3.SAFER SOLVENTS AND AUXILIARIES-

Eliminating volatile organic solvents by shifting to water-based system, solvent-free reaction or supercritical carbon dioxide.

4.DESIGN FOR ENERGY EFFICIENCY-

Lowering reaction temperature and pressures through high-efficiency catalysts, which reduces the fossil-fuel energy combustion responsible for greenhouse gas emission.

Green chemistry matrics-

When evaluating hazardous gases such as cl2, co, cocl2, so2, no or volatile organic compounds. The process matrix applies localized scoring configuration to track risk parameters:

Assessment metric	Evalution Criteria for Gases	Green chemistry target
Inherent Toxicity (GHS/SDS)	Categorizes the acute inhalaton toxicity, corrosivity, and carcinogenic risk of the gas.	Replace highly toxic gases with benign alternative in-situ generated, short-lived intermedia
Physical hazard/ volatility	Evaluates vapor pressure, flashpoints, and explosion/flammability limits under process condition.	Run reacton at ambient temperature and pressure to limit gas expansion pressurized containmenated risks.
Process footprint/ emissions	Tracks the exact node in the process network where the gas is evolved as a byproduct.	Utilize real-time monitoring (principle 1 to optimize reaction and elimination of gaseous as byproducts.
Accident potential (principle 12)	Assesses the risk of catastrophic release, fire, or explosion (historically drawing lessons from events like the Bhopal tragedy).	Substitute bulk storage of compresses hazardous gases with safer physical forms.

Green chemistry Principle of toxic gases elimination-

Principle 1

Eliminating toxic gaseous side-products.

Principle 3

Replacing gaseous phosgene with liquid organic carbonates.

Principle 9

Employing selective solid heterogeneous catalysts to favor benign ration channels over hazardous gasevolving pathways.

Principle 12

Operating under conditions where pressure, temperature, and physical form minimize catastrophic release risks.

Replacement Strategies for Ultra-Hazardous es gas

Eliminating phosgene

Phosgene is an insidiously toxic gas widely used in polymer and pharmaceutical synthese

Applications of hazardous gases-

Application of hazardous gases span industrial manufacturing, emergency response, and environmental management. Where these material are either utilized purposefully or monitored as dangerous byproducts.

Common applications and uses

1.Manufacturing and chemical synthesis:

Industries use reactive and specialty gases (like chlorine or hydrogen) as feedstocks to produce plastics, pharmaceuticals, and agricultural chemicals.

2. Purging and Blanketing:

Inert gases like nitrogen and argon are applied to pipelines and storage tanks to displace oxygen and prevent accidental explosions.

3.Metal processing and welding:

Carbon dioxide and acetylene serve as shielding or fuel gases in commercial cutting and welding operations.

Safety and monitoring applications

1.Fire and rescue operation:

Real-time toxic and harmful gas monitoring systems track toxic plumes at disaster scenes to guide firefighter routing and ensure safety.

2.Industrial hygiene:

Advanced tools lie the drager x-pid portable detector measure trace levels of hazardous volatile organic compounds in workplaces.

3.Confined space and infrastructure:

Lot sensor networks monitor sewer systems and drainage vaults for deadly buildups of hydrogen sulfide and methane Advantages regarding hazardous gases-

1.Zero toxic emissions:

Replaces toxic industrial gases (such as chlorine gas used in paper bleaching) with safer alternatives like hydrogen peroxide (H2O2).

2.Lower air pollution:

Reduces smog, ozone depletion, and greenhouse gas emission by avoiding volatile organic compounds (VOCs) and harmful exhaust.

3.Safer workplaces:

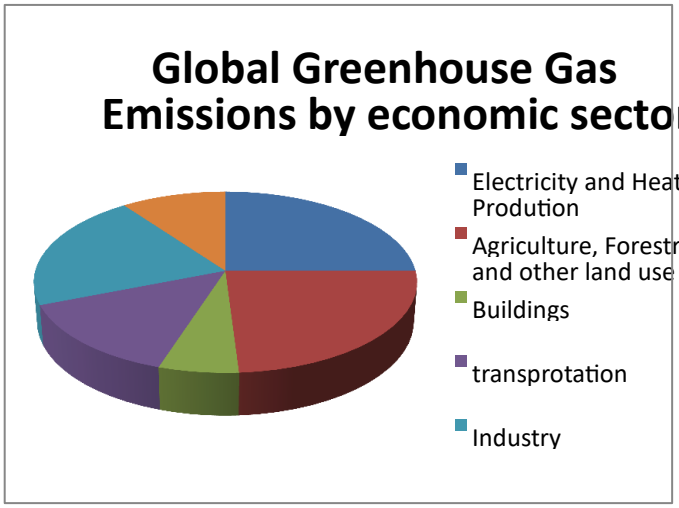
Eliminates accidental gas leaks and explosions, keeping factory workers safe from dangerous chemical exposures.

4.Benign solvents:

Replaces harmful halogenated gas-producing solvents with supercritical carbon dioxide (SO2) or waterbased systems.

5.Cleaner air and water:

Stops toxic pollutants from entering the atmosphere and local water supplies, protecting flora and fauna.



Conclusion-

Green chemistry provides a powerful flamework for improving the stainability of hazardous gases prevension, less hazardous chemical synthesis, safer solvent and auxiliaties, Design for green efficiency, and environmental impact their advantages and application for the improve air quality and rescue the climatic cycle and use no. lickage of harmful gaseous. Green chemistry offers a practical roadmap to address the hazards associated with industrial gases. By replacing compressed toxic gases with non-toxic solid/liquid surrogates, utilizing continuous microfluidic flow reactors, and developing heterogeneous catalytic pathways for carbon utilization, industrial operations can improve chemical safety while lowering environment impact.

References-

1. Ganesh, Krishna N., Deqing Zhang, Scott J. Miller, Kai Rossen, Paul J. Chirik, Marisa C. Kozlowski, Julie B. Zimmerman et al. “Green chemistry: a framework for a sustainable future.” *Organometallics* 40, no. 12 (2021): 1801-1805.
2. Anastas, P. T., & Kirchhoff, M. M. (2002). Origins, current status, and future challenges of green chemistry. *Accounts of chemical research*, 35(9), 686-694.
3. Matus, K. J. M. (2009). *Green chemistry: A study of innovation for sustainable development*. Harvard University.

4. Anastas, P. T., & Beach, E. S. (2007). Green chemistry: the emergence of a transformative framework. *Green Chemistry Letters and Reviews*, 1(1), 9-24.
5. Chen, T. L., Kim, H., Pan, S. Y., Tseng, P. C., Lin, Y. P., & Chiang, P. C. (2020). Implementation of green chemistry principles in circular...
6. ...271-293.
7. Matus, K. J., Xiao, X., & Zimmerman, J. B. (2012). Green chemistry and green engineering in China: drivers, policies and barriers to innovation. *Journal of Cleaner Production*, 32, 193-203.
8. Andraos, J., & Matlack, A. S. (2022). *Introduction to green chemistry*. CRC press.
9. Valavanidis, A. (2016). Green Chemistry and New Technological Developments. *New Avenues for the Green Economy and Sustainable Future of Science and Technology*, 1, 1-33.
10. Tiwari, A. (2023). Advancement of materials to sustainable & green world. *Advanced Materials Letters*, 14(3), 2303-1724.
11. Matus, K. J., Clark, W. C., Anastas, P. T., & Zimmerman, J. B. (2012). Barriers to the implementation of green chemistry in the United States. *Environmental science & technology*, 46(20), 10892-10899.