Fabrication of novel zeolite NaA/$MgFe_2O_4$ nanocomposite catalyst for the effective removal of chemical warfare nerve agent simulant

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Abstract
The aim of present study is to investigate the effective removal of chemical warfare nerve agent simulant dimethyl methyl phosphonate from water solution by the novel zeolite NaA/MgFe2O4 nanocomposite catalyst.For the purpose, MgFe2O4 nanoparticles were successfully fabricated over the zeolite NaA via the hydrothermal method and identified using FESEM, EDAX, XRD, FTIR and AFM analyses.
The performance of the NaA/MgFe2O4 nanocomposite catalyst was then evaluated for the removal (adsorption and degradation) of DMMP agent simulant and monitored by using a GC-FID technique.
Furthermore, the influence of different parameters involving contact time, initial concentration, adsorbent dose, and catalyst type on the removal of DMMP were investigated. The obtained outcomes from GC-FID analysis verified the maximum removal more than 96% for DMMP agent simulant. The parameters including: contact time (40 min), adsorbent dose (0.1 g), and initial concentration (50 mg/L) were gained as the optimized amounts for the removal reaction. Additionally, the non-toxic methyl phosphoric acid (MPA) as the degradation reaction product of the DMMP by the NaA/MgFe2O4 catalyst was identified.

Keywords: Zeolite, Chemical warfare, Catalyst, Nerve agent.

INTRODUCTION

Zeolites are hydrated aluminosilicate minerals made from interlinked tetrahedra of alumina (AlO_4) and silica (SiO_4).
In simpler words, they're solids with a relatively open, three-dimensional crystal structure built from the elements aluminum, oxygen, and silicon, with alkali or alkaline-Earth metals (such as sodium, potassium, and magnesium) plus water molecules trapped in the gaps between them. Zeolites form with many different crystalline structures, which have large open pores (sometimes referred to as cavities) in a very regular arrangement and roughly the same size as small molecules.
There are about 40 naturally occurring zeolites, forming in both volcanic and sedimentary rocks; according to the US Geological Survey, the most commonly mined forms include chabazite, clinoptilolite, and mordenite. Dozens more artificial, synthetic zeolites (around 150) have been designed for specific purposes, the best known of which are zeolite A (commonly used as a laundry detergent), zeolites X and Y (two different types of faujasites, used for catalytic cracking), and the petroleum catalyst ZSM-5 (a branded name for pentasil-zeolite).

What special properties do zeolites have?

Zeolites are very stable solids that resist the kinds of environmental conditions that challenge many other materials. High temperatures don't bother them because they have relatively high melting points (over 1000°C), and they don't burn. They also resist high pressures, don't dissolve in water or other inorganic solvents, and don't oxidize in the air. They're not believed to cause health problems through, for example, skin contact or inhalation, though in fibrous form, they may have carcinogenic (cancer-causing) effects. Since they're unreactive and based on naturally occurring minerals, they're not believed to have any harmful environmental impacts. Although zeolites might sound incredibly boring, their stable and unreactive nature isn't what makes them useful.