

Photocatalytic degradation of Methyl Orange dye using Chitosan Alumina Composite under Sunlight irradiation

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Abstract

Photocatalytic degradation of methyl orange as a pollutant in wastewater samples is investigated in this study. This photo degradation is investigated using Chitosan Alumina Composite (CAC) under solar irradiation method. The batch mode parameters such as effect of contact time, effect of pH, effect of composite dose and effect of initial dye concentration are studied. The maximum degradation efficiency for methyl orange on CAC is 92.48% at 90 minutes. Equilibrium data are well fitted with Langmuir and Freundlich isotherm models. The maximum degradation capacity at equilibrium condition q_e is 22.75 mg/g.

Furthermore, the adsorption kinetics of methyl orange is analysed and the rate of adsorption is found to confirm the pseudo first order kinetics with a good correlation regression coefficient ($R^2=0.9904$). The results showed that CAC can be attractive option for dye degradation from industrial effluents.

Keywords: Methyl Orange, Chitosan Alumina Composite, Solar irradiation, Degradation, Pseudo first order kinetics.

Introduction

Water is the most essential compound for life because it is necessary for various activities which include drinking, agriculture, energy, industry and public hygiene. Due to increasing population, the fresh water resources are diminishing by over utilization of water¹. Industrial activities and rapid growth of population increase the number of contaminants in the environment, so nowadays, it becomes big challenge to conventional wastewater treatment process^{2,3}. Discharge of effluents from various industries causes adverse effects to human beings as well as plants and animals. Methyl Orange is an anionic dye with the molecular formulae of $C_{14}H_{14}N_3NaO_3S$. The structure of methyl orange is given below:

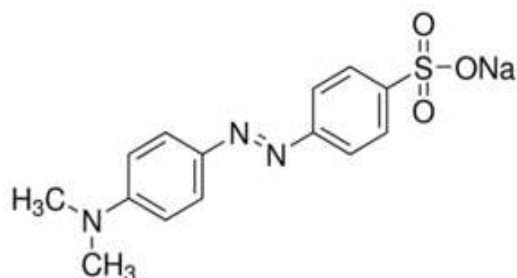


Fig. 1: Chemical Structure of Methyl Orange

Methyl Orange is commonly used in printing, leather, paper, foodstuffs, cosmetics and textile industries. In laboratories methyl orange is used as an acid base indicator. Discharge of methyl orange in to the aquatic environment produces health problems in plants, animals and human beings due to its non-biodegradability in nature. If the methyl orange is inhaled by human being, it causes skin, eye and digestive path irritation.

Therefore, it is very essential to remove methyl orange from the wastewater⁴. Generally industrial effluents are treated by using coagulation, flocculation, reverse osmosis, filtration, evaporation, chemical precipitation, electro dialysis, advanced oxidation and photocatalytic degradation⁵. Among all the methods, photocatalytic degradation using sunlight is the simple and efficient method for the degradation of dyes in aqueous phase. The natural and abundant energy of the world is solar energy. Instead of artificial light like UV and visible, solar energy can be used as an alternative energy source because the use of artificial light requires high electric power and it cause health hazards⁶. Photocatalytic degradation using sunlight does not produce sludge which is the main advantage of this method.

After cellulose, chitosan is the second abundant polymer in nature. It dissolves only in acidic solutions due to the interaction of intra and inter molecular hydrogen bonding between H^+ and $-NH_2$. Chitosan contains modifiable position in its structure. So, the degradation ability of modified chitosan is greater than raw chitosan⁷. In this research work chitosan is modified with alumina. Alumina has good atmospheric property, so superior alumina is modified with chitosan for the degradation of dyes. The modification of chitosan with alumina increases the pore size and surface area of the composite. The preparation, physiochemical and surface characteristics of CAC are reported in our previous paper⁸. The main scope of this study is to examine the degradation ability of CAC for the degradation of methyl orange from aqueous solutions.

Material and Methods

An anionic dye methyl orange is used for degradation having molecular formula: $C_{14}H_{14}N_3NaO_3S$ and λ_{max} 460-520 nm, Chitosan, Aluminium nitrate, Acetic acid, Ammonium Hydroxide, Sodium Hydroxide (NaOH) and Hydrochloric Acid (HCl) are purchased from Universal Scientific Company, India. The purchased chemicals and reagents are in analytical grade, which can be used without further purification. Double distilled water is used in the entire studies.