Comparison of Photocatalytic Activity of Ecofriendly Fabricated AgNPs & TiO_2NPs

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Abstract— One of the major threats in the aquatic ecosystem is the pollution caused by organic dyes which are widely used in textile, plastic, medicine and in many other industries. Accumulation of these dyes in the water bodies causes eutrophication and cause severe damage to the aquatic organism. The removal of these non-biodegradable organic chemicals from the environment is a crucial ecological problem. Photo catalytic activity of biosynthesized AgNPs and TiO_2NPs was evaluated by degradation of methyl orange under solar irradiation. Dye degradation was visually detected by gradual change in the colour of the dye solution from deep orange to light orange to colorless. An increase in the rate of reduction of dye was observed with the increase in concentration of catalyst (AgNPs and TiO2NPs).

Key words: Organic Dyes, AgNPs, TiO_2NPs, Photo-Catalysis

I. INTRODUCTION

Photo catalysis is an economically attractive and environmentally safe technology of advanced oxidation process for removal of organic impurities from water. During this process, the semiconductor illuminated by light of the proper wavelength absorbs light and generates active species, which oxidize the organic compounds dissolved in water [1]. This process does not yield toxic intermediate products making it suitable for cleaning aquatic environment that contains low to medium contaminants [2].

Accumulation of dyes in the water bodies from textile, plastic, medicine and in many other industries causes eutrophication and cause severe damage to the aquatic organism. They are also resistant to microbial attack [3]. The removal of these non-biodegradable organic chemicals from the environment is a crucial ecological problem. Many techniques, such as activated carbon sorption, flocculation, electrocoagulation, UV-light degradation and redox treatments, are being routinely used for abating dyes [4]. However, due to the ineffectiveness of these techniques in some way or the other, the present scenario requires better and improved wastewater treatment measures. Recently, metal nanoparticles were reported as effective photocatalysts for degrading organic dyes, under ambient temperature with visible light illumination [5]. This can be achieved by increasing the optical path of photons leading to a higher absorption rate of nanoparticles in the presence of electrical field [6]. These nanoparticles showed new and improved properties based on their morphological structures and characteristics as compared to bulk materials [7].

The most popular and promising material for this application is TiO_2 because of its high physical and chemical stability and non-toxicity [8]. Literature also suggests AgNPs as good choice for removal of organic dyes than the common dye removal techniques [9]. [10] Stated that, Ag nanoparticles are good, highly efficient and stable photocatalysts under ambient temperature with visible light illumination for degrading organic compounds and dyes. Methyl orange (MeO) is comparatively stable without photocatalyst under UV and outdoor irradiation. In textile and paper industry, recently AgNPs are used to degrade the organic dyes as they exhaust enhanced photocatalyst property [11] [4]. Report suggested that the removal of organic dyes using nanoparticles is better choice than common methods like redox treatments [9], electro-coagulation [12] carbon absorption [13] and UV photo-degradation [14].

The present work was carried out to study the photocatalytic degradation of methyl orange dye in the presence of synthesized AgNPs using the extract of seed coat of pigeon pea and TiO_2NPs using the seed soaked water of lentil.

II. MATERIAL & METHOD

Materials: Methyl orange dye (Hi, media), biosynthesized from seed coat of pigeon pea {PP (SC)-AgNPs} (Average size 12nm) and titanium dioxide synthesized from seed soaked of lentil {L-TiO_2NPs} (Average size 10nm).

A. Method [15]

The photo degradation activity of phytosynthesized AgNPs and TiO_2NPs was studied by degradation of methyl orange under sunlight irradiation. The dye solution was prepared by dissolving methyl orange (10mg/l) in distilled water. AgNPs/TiO_2NPs (2ppm and 4ppm) was added to 50ml dye solution of methyl orange and the colloidal mixture was stirred and kept under sunlight. A control was prepared and kept under the similar condition for comparing any change in colour of the dye solution. After a time interval of 30mins 2ml suspension was taken from the colloidal mixture and centrifuged at 5000rpm for 15minutes the O.D was taken at 492 (methyl orange) on spectrophotometer to study the dye degradation in presence of AgNPs/TiO_2NPs.

B. Results

Photo catalytic activity of biosynthesized AgNPs and TiO_2NPs was evaluated by degradation of methyl orange under solar irradiation. Dye degradation was visually detected by gradual change in the colour of the dye solution from deep orange to light orange to colorless (Fig. 1). The control exhibited no change in coloration during exposure to sunlight. The percentage dye degradation was calculated using the formula,

$$\text{Dye degradation (\%)} = [(C_0-C_t)/C_0] \times 100$$

Where C_0 is the initial concentration of the dye, C_t is the concentration of the dye solution after 't' hrs of exposure to solar irradiation.

AgNPs/TiO_2NPs with sunlight was proven to be very effective for degradation of organic dyes. The effect of different catalyst dosage was analyzed keeping the rate of parameters constant. The degradation of Methyl orange was faster with increasing concentration of the catalyst

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(AgNPs/TiO_2NPs). AgNPs exhibited slightly high photocatalytic activity compared to TiO_2NPs.

97.1% degradation of Methyl orange was observed when treated with 2ppm of AgNPs at 4hrs.Incorporation of 2ppm of TiO_2NPs resulted in 91.2% degradation of Methyl orange at 4.5hrs. However with 4ppm of TiO_2NPs 96.2% degradation of Methyl orange at 4 hrs was observed (Table 1and Fig. 1).

In the present study increase in the rate of reaction was observed with the increase in the concentration of the nanoparticles (catalyst).

Table 1 Photocatalytic degradation of methyl orange dye by AgNPs/TiO_2NPs

Time in hrs	AgNPs				TiO_2NPs			
	2ppm		4ppm		2ppm		4ppm	
	O.D	% Degradation	O.D	% Degradation	O.D	% Degradation	O.D	% Degradation
Con.	1.05	0	1.03	0	1.03	0	1.04	0
0	1.05	0	1.03	0	1.03	0	1.04	0
0.5	0.99	5.7	0.98	4.8	0.96	6.7	1.01	2.8
1	0.89	15.2	0.87	15.5	0.88	14.5	0.85	18.2
1.5	0.73	30.4	0.65	36.8	0.79	23.3	0.73	29.8
2	0.52	50.4	0.48	53.3	0.55	46.6	0.53	49.9
2.5	0.38	63.3	0.23	77.6	0.48	53.3	0.38	63.4
3	0.25	76.1	0.08	89.3	0.37	64.0	0.21	79.8
3.5	0.15	85.7	0.002	99.8	0.28	72.8	0.09	91.3
4	0.03	97.1	-	-	0.17	83.4	0.04	96.15
4.5	-	-	-	-	0.09	91.2	-	-

Table 1:

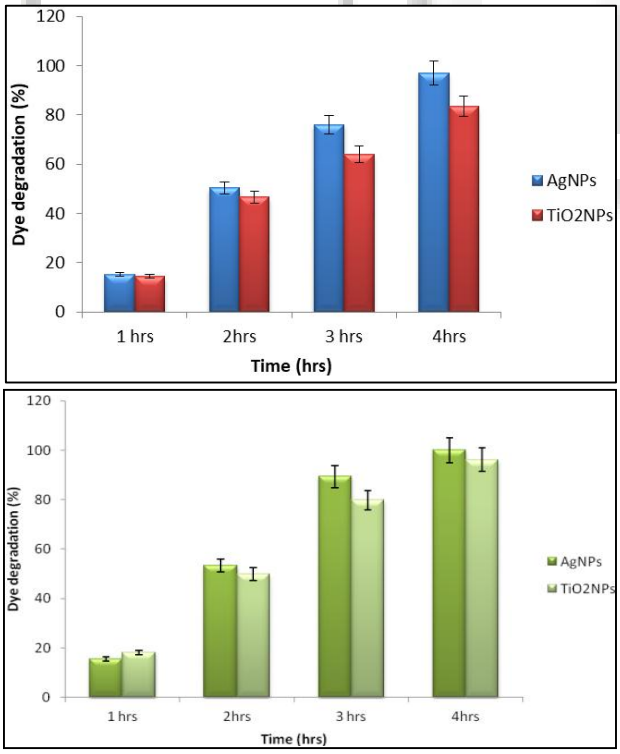

Fig. 1: Methyl Orange Dye Degradation by AgNPs and TiO2NPs (a) 2ppm and (b) 4ppm (bar Graph Indicated the ±SD)

The dissolved oxygen molecules in the reacting medium accept the excited electrons from the particle surface and are converted into oxygen anion radicals. These radical breaks the simple organic dye in to simpler organic molecules leading to the rapid degradation of the dye [16] [17].

[18] Reported the decolorisation of Congo red by Aspergillus niger synthesized silver nanoparticles. Reduction of Bismarck Brown R dye by sol-gel method synthesized TiO_2 nanoparticles was reported [19]. [2] Reported a comparative analysis of photocatalytic degradation of methylene blue dye by zinc oxide and titanium dioxide nanoparticles. The photocatalytic degradation activity of Azardirachta indica leaf extract-mediated colloidal TiO_2NP against methyl red dye solution was studied by [20]. Photocatalytic Degradation of Pharmaceutical Compounds using TiO_2NP was reported by [21].

III. Conclusion

Selected AgNPs and TiO_2NPs, fabricated from organic waste were evaluated for their photocatalytic ability to degrade methyl orange under solar irradiation. Dye degradation was initially visualised by the gradual change in the colour of the dye solution from deep orange to light orange to colourless.

AgNPs exhibited slightly high photocatalytic activity compared to TiO_2NPs.

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