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Research paper

Degradation of municipal wastewater using photocatalytic silica Nano particles

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Abstract

The main objective of this work is to degrade the wastewater by using photo catalytic nano particles. The photo catalytic nano particles works under UV light and degrade the organic compounds that are present in municipal wastewater. The commonly used photocatalytic nano particles are silicon dioxide, platinum, silver nanoparticles, zinc oxide etc. These nano particles are produced by different methods like sol-gel process, chemical vapor deposition etc. and are characterized by different characterization techniques like X-ray diffraction (XRD), Scanning Electron Microscopy (SEM), Energy Dispersive Studies (EDS), Transmission Electron Microscopy (TEM) etc. In the present study silicon dioxide (SiO2) nanoparticles were synthesized by sol gel technique and characterized using SEM and XRD. The nanoparticles synthesized were used for the treatment of municipal wastewater. The degradation of the wastewater is evaluated based on the parameters such as degradation temperature, wastewater concentration, amount of nano particle added and time of degradation. COD analysis was carried to estimate the percentage of degradation of wastewater. It has been confirmed that photocatalytic silica nano particles can be used for the degradation of municipal wastewater. It was also observed that a higher degradation percentage of was obtained by this method as compared to the activated sludge process of treatment.

Keywords: *Degradation; Photo Catalysis; Silicon Dioxide Nanoparticles; Sol-Gel; Wastewater.*

1. Introduction

The latest decades progress in catalytic materials has made it possible to design new functionalized surfaces for specific applications. This field is one of the most rapidly growing research areas within nanotechnology, as the surfaces achieve unique physical and chemical properties, when the crystal dimension reaches the nano scale [1], [2]. An important mechanism of some of these new functional nano materials is the catalytic property [3]. The catalyst enhances chemical reactions, without itself being consumed or changed. In other words the catalytic materials can be utilized to decompose [4 - 7] larger organic molecules. This property has a significant innovation potential, as it is possible to use these nano crystalline materials to degrade filth and microorganisms. The photocatalytic materials, which are active in solar light, will be able to generate a chemical reaction during daylight and staying inactive in the nighttime [8 - 13]. The ceramic material silicon dioxide (SiO2) is an example of a photo catalyst, which is active, when it is exposed to the right light source. Here the wavelength of the light must be less than 400 nm, i.e. UV-light. The photocatalytic property makes SiO2 a potential candidate for decomposition of organic compounds in wastewater.

Large amount of untreated effluent is being let out in the river bodies and water bodies, which is affecting the aquatic life adversely. Photo-catalytic nano-particles can be used to treat this effluent. Thus the effluent could be made less harmful to the aquatic life and pollution in the water bodies could be reduced. In the present work, municipal wastewater with high COD values was treated using Silicon dioxide photo catalytic nano particles. The nanoparticles were synthesized by sol-gel technique and characterized by SEM and XRD at Osmania University, Hyderabad. The municipal wastewater was collected from BVRIT Narsapur Medak District.

2. Experimental procedures

Synthesis of silicon dioxide nanoparticles

Nanoparticle were synthesized by Sol-Gel technique [13]. To 10 ml of tetra ethyl orthosilicate ethanol and distilled water are added. Ammonia solution is added to this in a drop wise manner while stirring. The stirring should be done continuously. The precipitate formed is filtered and dried in hot air oven. The dried particles are sintered in muffle furnace at 800oC.

Characterization

The synthesized nanoparticles were characterized using SEM (Fig 1) and XRD

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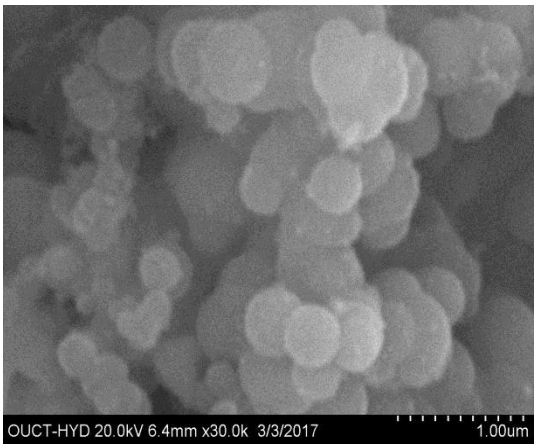


Fig. 1: SEM Image of Silica Particles.

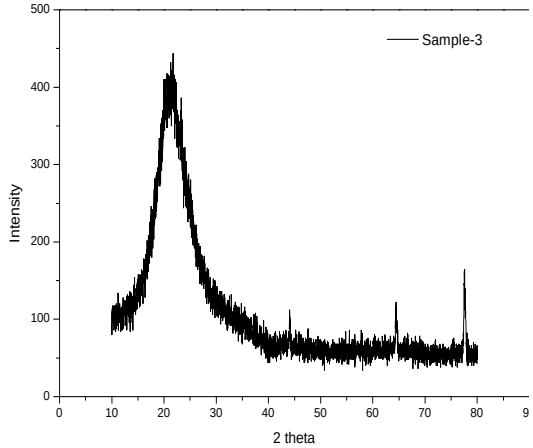


Fig. 2: XRD Characterization of Silica Particles.

(Fig 2) at Osmania University, Hyderabad, India. It was confirmed that the synthesized nanoparticles were amorphous silica in the size is around 100nm.

3. Degradation of wastewater based on various parameters

Municipal wastewater was collected from STP, BVRIT, Narsapur, Medak District, Telangana, India. The physico-chemical data of the collected wastewater is presented in Table I.

Table 1: Physiochemical Properties of Municipal Waste Water

S. No	Parameters	Prevailing range
1	COD	480 PPM
2	P^H	6.1

Parametric studies

Degradation of the wastewater was conducted based on four parameters such as amount of photocatalyst, time of degradation, concentration of wastewater, and degradation temperature. Design of experiments was done using 2^K factorial where K=4. Degradation of the effluent was estimated at two levels of each of the four parameters.

Degradation of the wastewater using Silicon dioxide photocatalytic nano particles

The photocatalytic activity of photo catalytic nano materials was studied for the degradation of municipal effluent. The photocatalytic reaction was carried out in a 250 ml conical flask containing the nano particles (0.05g, 0.25g) along with 20 ml of wastewater and continuously stirred for different time interval (2hr, 4hr, 6hr) by means of a magnetic stirrer in the presence of UV light. The treated water was filtered to remove nanoparticles.

COD analysis was carried out before and after the treatment of wastewater using photocatalytic nano particle silicon dioxide. COD value is estimated using the equation (1).

$$\mathrm{COD} = \frac{\left(\left(\begin{matrix}\text{blank titer value}-\\ \text{wastewater titer value}\end{matrix}\right)*0.8*1000\right)}{10} \quad (1)$$

4. Results and discussion

Adding silicon dioxide nano particles in the presence of UV light, with continuous stirring, degradation of the wastewater was carried out varying the parameters such temperature, amount of nanoparticles added, concentration of wastewater, and time. The degradation percentages are tabulated in the table II along with the parameters varied.

The COD values are given by,

Blank (distilled water) titer value= 10.4 ml

Wastewater titer value before adding nano particles = 4ml

Wastewater titer value after adding nano particles =7.9ml

COD value before adding nano particles =480 ppm

Effluent COD value before adding nano particles=168ppm

Percentage degradation= 65%

From the above degradation studies it is observed that maximum degradation 65% was obtained with O.25 g of silicon dioxide, time 4 hours, wastewater concentration of 100% and room temperature (R.T).

Table 2: Percentage Degradation of Wastewater Based on Various Parameters

Experiment No.	Parameters Mass of silicon dioxide, g	Time, h	Concentration of effluent, Wt%	Temperature, ^oC	% Degradation
1	0.05	2	50	R.T	5
2	0.05	2	50	50	11.66
3	0.05	2	100	50	13.33
4	0.05	4	100	50	15
5	0.25	4	100	50	33.33
6	0.25	2	100	50	28.33
7	0.25	2	50	R.T	31.66
8	0.25	2	100	R.T	36.66
9	0.25	2	50	50	40
10	0.25	4	50	50	48.33
11	0.25	4	50	R.T	58.33
12	0.05	2	100	R.T	25
13	0.05	4	50	50	28.33
14	0.05	4	50	R.T	61.66
15	0.25	4	100	R.T	65
16	0.05	4	100	R.T	41.66

5. Conclusions

In this study we set out to investigate the degradation of municipal wastewater using silicon dioxide photocatalytic nano particles. Degradation of wastewater is carried out based on four parameters such as amount of photocatalyst, time of degradation, concentration of wastewater, and degradation temperature.

From the above degradation studies it is observed that maximum degradation 65% was obtained with O.25 g of silicon dioxide, time 4 hours, wastewater concentration of 100% and room temperature. COD values of the wastewater have been reduced from 480ppm to 168 ppm, as well as the effluent has been neutralized.

It has been confirmed that this process as compared to activated sludge process (reduction in COD is around 54% as found from STP water at BVRIT Narsapur) can achieve higher degradation of the toxic materials present in the effluent.

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