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Basic Fuchsine Dye Degradation Using (1:3, 1:4) N-TiO_2 Photocatalysts

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Abstract

Photocatalyst preparation using titanium dioxide and urea in the ratio of 1:3, 1:4 at ranges of different temperature was investigated in this work. Basic fuchsine dye which is a staining dye had been subjected to photodegradation using artificial lamp of 200W. The photocatalysts prepared under different temperatures was applied to the dye at different concentration to find decrease in the rate of absorbance from the dye's initial range. The photocatalysts prepared were analyzed using ultraviolet-visible light spectroscopy, infrared spectroscopy, energy dispersive X-ray studies and X-ray diffraction studies and scanning electron microscopic studies. The photodegradation by the N-TiO_2 photocatalysts revealed efficient degradation in the basic fuchsine dye.

Keywords: dye, photodegradation, photocatalyst, urea, titanium dioxide.

1. Introduction

Researchers have been done over the past decades in the quality of water and billions do not have basic sanitation of water [1] .The water ways has polluted along with ruining aquatic lives and earthly habitats which leads to lack of nutrients which can be experienced lively. Reverse osmosis techniques takes away the essential nutrients of water along with the pollutants [2]. Dyes have become a part of water pollution through textile industries, petrochemical industries, dye manufacturing industries and there is a need to reduce the effects of the harmful chemicals which is involved in it [3]. The photodegradation process studies the reduction of intensity in the dye solutions.

2. Review of Literature

Linsebigler et al., has issued a publication on 'photocatalysis on TiO_2 surface: Principles, Mechanisms and selected results' which studies the band structure and concludes that the change in the surface of the photocatalytic structure that can alter the chemical events and bring about better photoexcitation of the molecules involved [4].

3. Materials and Methods

Dye-Basic Fuchsine (Sigma Aldrich), purified water, Titanium dioxide (Sigma Aldrich), Urea (Spectrum Chemicals), hydrochloric acid for cleaning purposes.

Experimental Procedure

Titanium dioxide and urea was taken in the ratio of 1:3, 1:4; at first the urea was dissolved in double distilled water then titanium dioxide was added to it, stirred, kept in dark for a night; this mixture was subjected to steaming by a steam bath at 100^0C. The dried sample was scrapped off and transferred to a muffle furnace crucible and kept at 400^0C, 500^0C and 600^0C. This nitrogen doped photocatalysts prepared was used in the photodegradation of basic fuchsine dye and the absorbance was checked for every half an hour for 3 hours [5].

4. Results and Discussion

Infrared Spectroscopy of 1:3, 1:4 N-TiO_2 photocatalyst

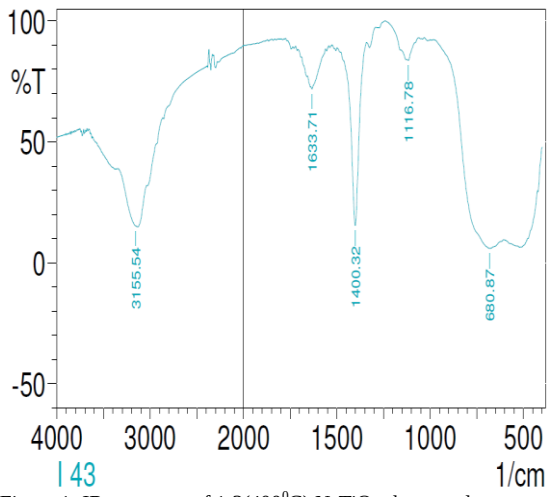

Figure 1: IR spectrum of 1:3(400^0C) N-TiO_2 photocatalyst

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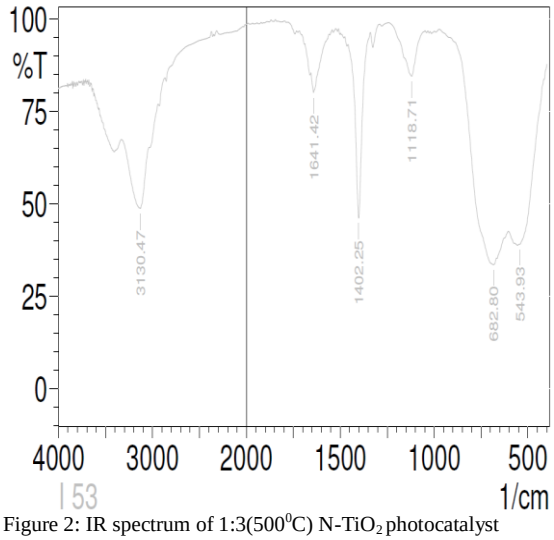

Figure 2: IR spectrum of 1:3(500^{0}C) N-TiO_2 photocatalyst

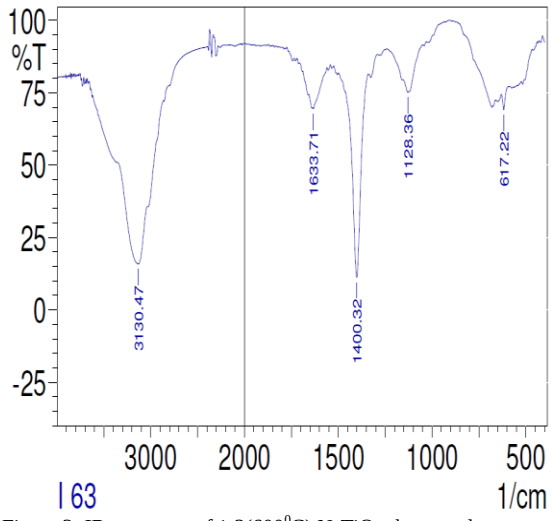

Figure 3: IR spectrum of 1:3(600^{0}C) N-TiO_2 photocatalyst

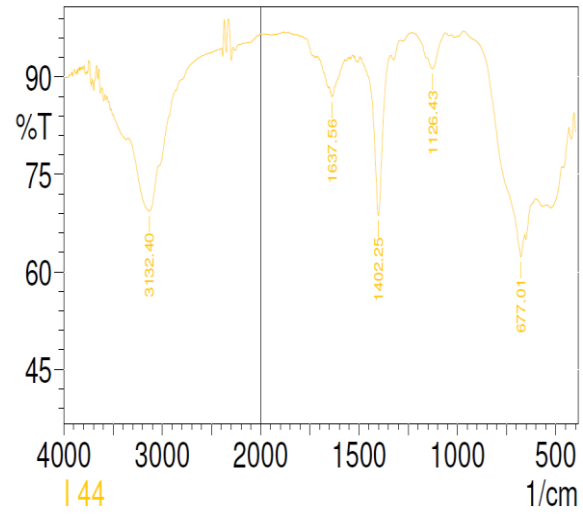

Figure 4: IR spectrum of 1:4(400^{0}C) N-TiO_2 photocatalyst

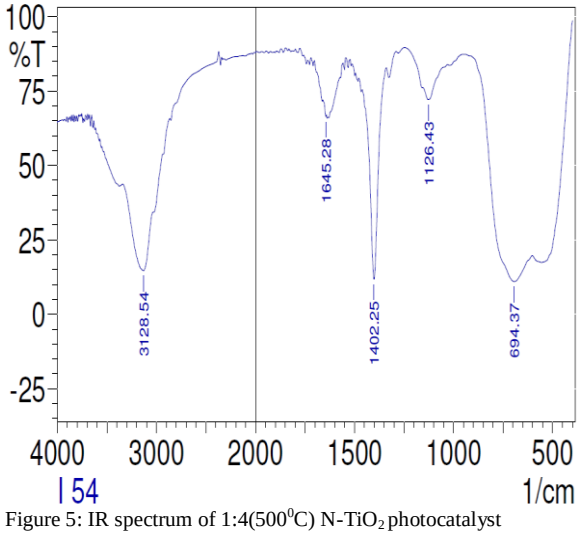

Figure 5: IR spectrum of 1:4(500^{0}C) N-TiO_2 photocatalyst

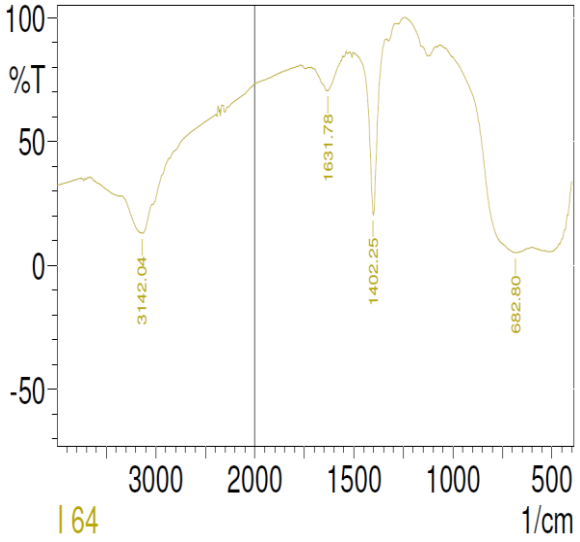

Figure 6: IR spectrum of 1:4(600^{0}C) N-TiO_2 photocatalyst

X-Ray Diffraction of 1:3, 1:4 N-TiO_2 photocatalyst

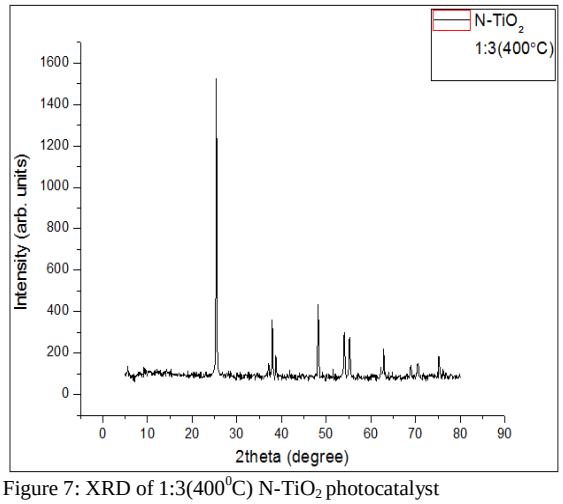

Figure 7: XRD of 1:3(400^{0}C) N-TiO_2 photocatalyst

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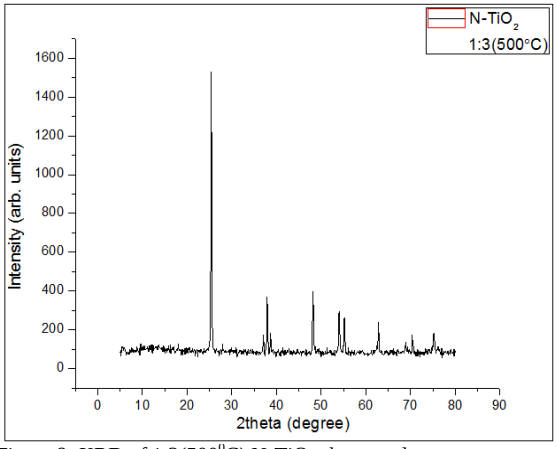

Figure 8: XRD of 1:3(500^{0}C) N-TiO_2 photocatalyst

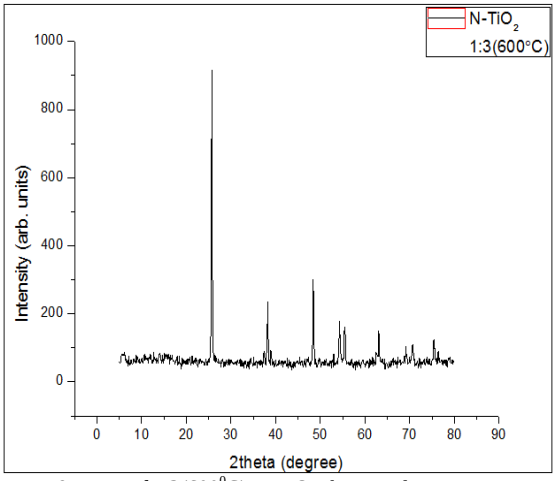

Figure 9: XRD of 1:3(600^{0}C) N-TiO_2 photocatalyst

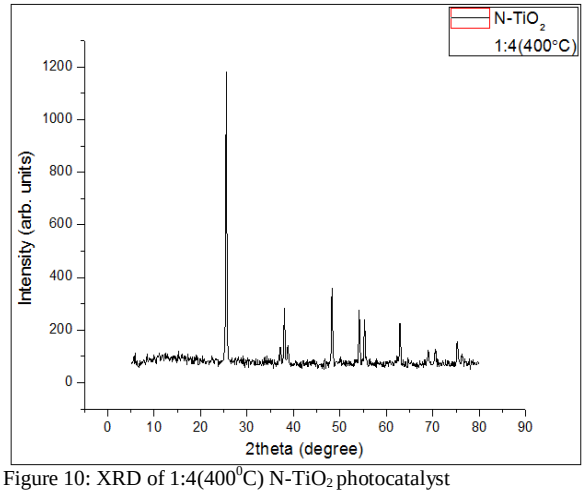

Figure 10: XRD of 1:4(400^{0}C) N-TiO_2 photocatalyst

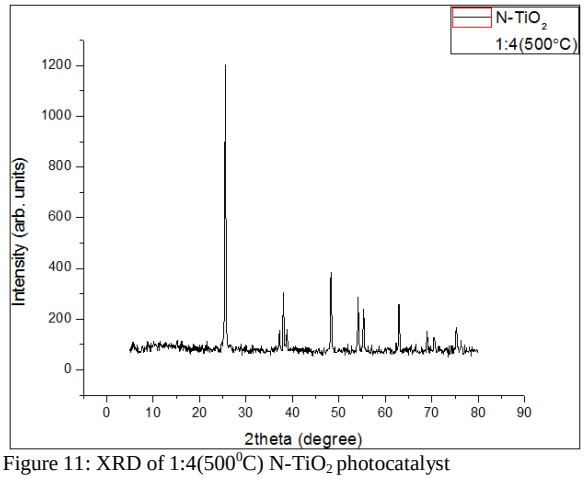

Figure 11: XRD of 1:4(500^{0}C) N-TiO_2 photocatalyst

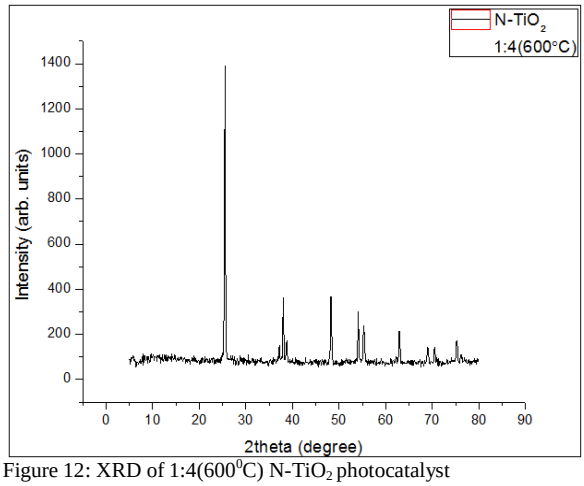

Figure 12: XRD of 1:4(600^{0}C) N-TiO_2 photocatalyst

Energy Dispersive Studies of 1:3, 1:4 N-TiO_2 photocatalyst

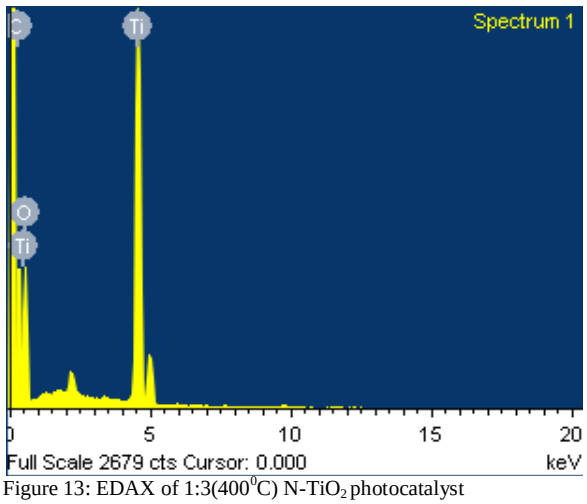

Figure 13: EDAX of 1:3(400^{0}C) N-TiO_2 photocatalyst

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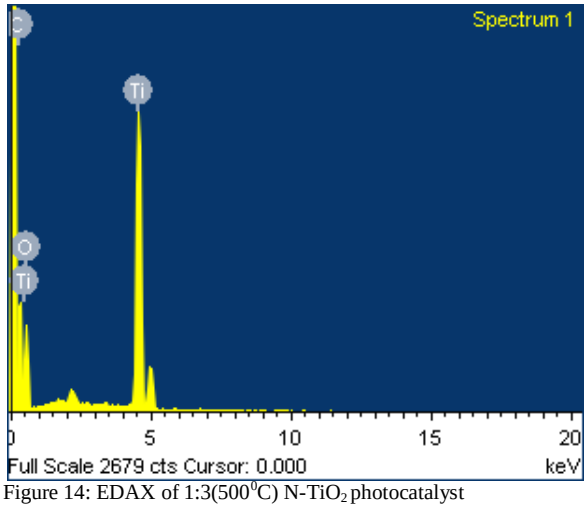

Figure 14: EDAX of 1:3(500^{0}C) N-TiO_2 photocatalyst

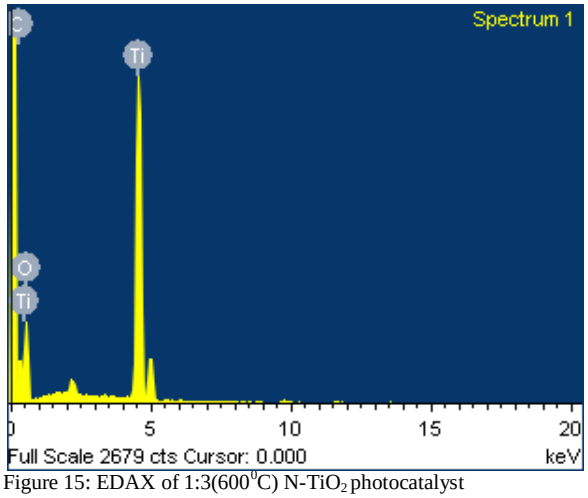

Figure 15: EDAX of 1:3(600^{0}C) N-TiO_2 photocatalyst

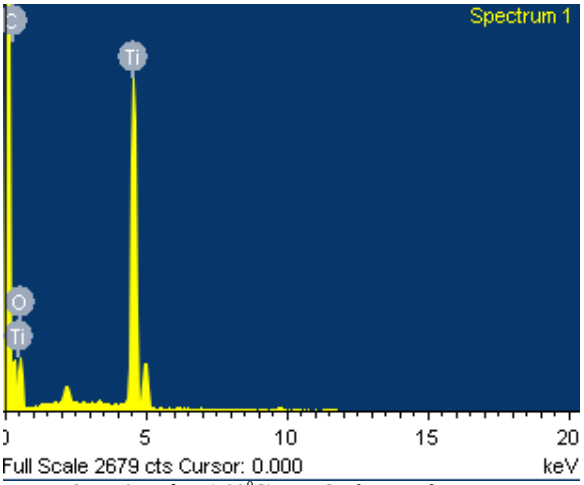

Figure 16: EDAX of 1:4(400^{0}C) N-TiO_2 photocatalyst

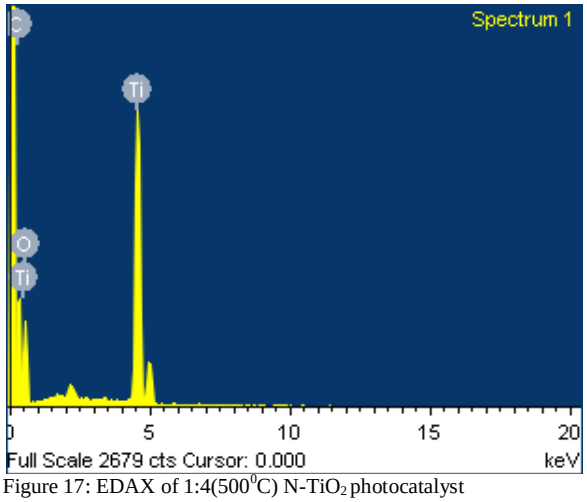

Figure 17: EDAX of 1:4(500^{0}C) N-TiO_2 photocatalyst

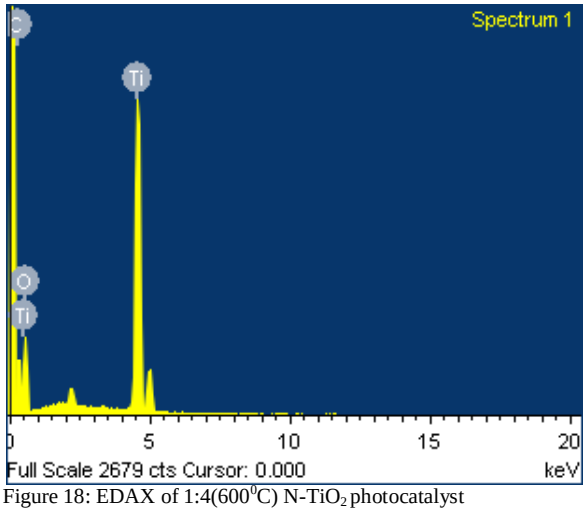

Figure 18: EDAX of 1:4(600^{0}C) N-TiO_2 photocatalyst

SEM Image of 1:3, 1:4 N-TiO_2 Photocatalyst

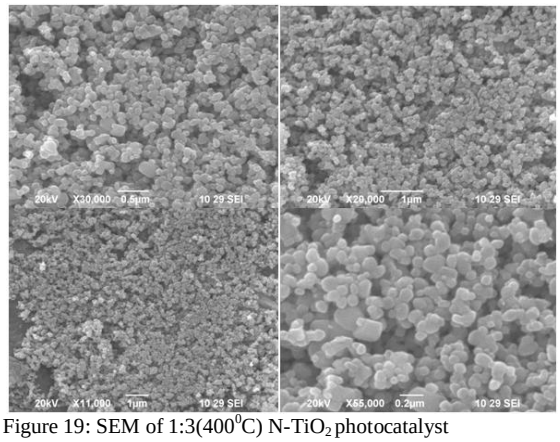
Figure 19: SEM of 1:3(400^{0}C) N-TiO_2 photocatalyst

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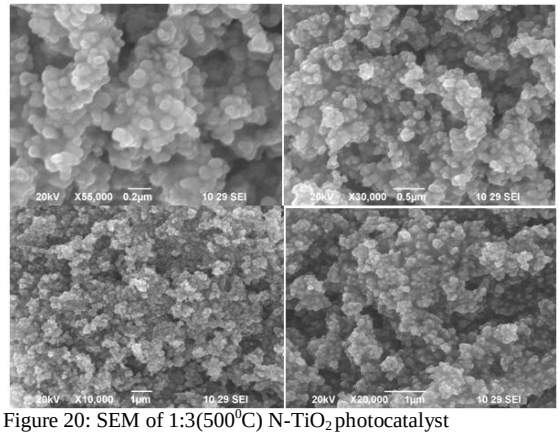

Figure 20: SEM of 1:3(500^{0}C) N-TiO_2 photocatalyst

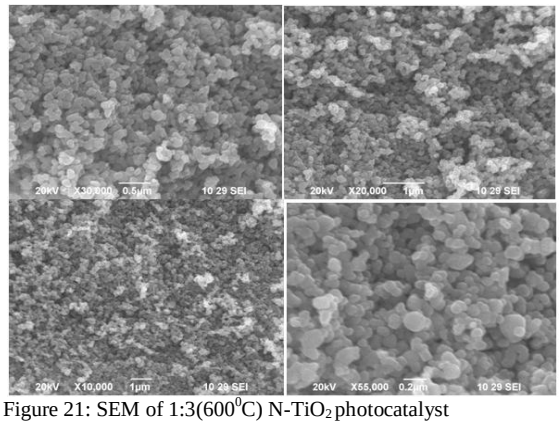

Figure 21: SEM of 1:3(600^{0}C) N-TiO_2 photocatalyst

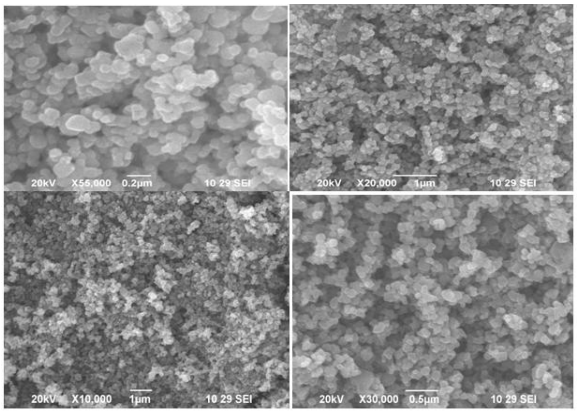

Figure 22: SEM of 1:4(400^{0}C) N-TiO_2 photocatalyst

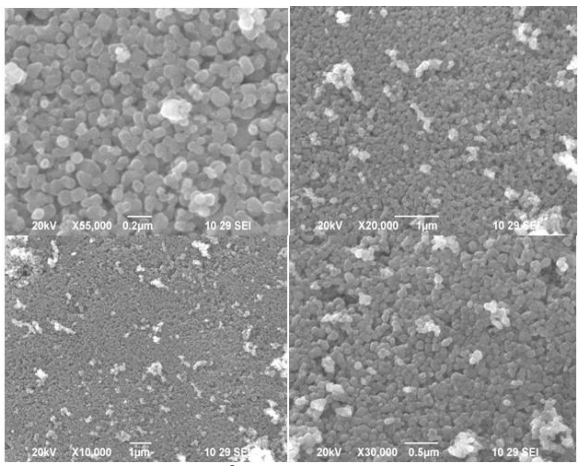

Figure 23: SEM of 1:4(500^{0}C) N-TiO_2 photocatalyst

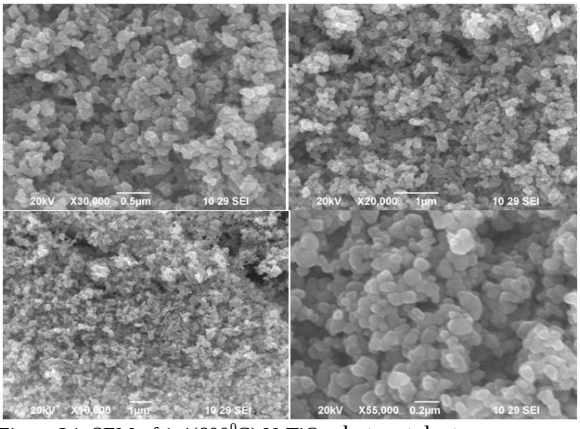

Figure 24: SEM of 1:4(600^{0}C) N-TiO_2 photocatalyst

Figure 1 has a sharp band at 1400.32 with an intensity of 15.398. Figure 2 has a sharp band at 1402.25 with an intensity of 46.02. Figure 3 has a sharp band at 1400.32 with an intensity of 11.222. Figure 4 has a sharp band at 1402.25 with an intensity of 68.659. Figure 5 has a sharp band at 1402.25 with an intensity of 11.751. Figure 6 has a sharp band at 1402.25 with an intensity of 20.334. Figure 7 has strongest peak at 25.4007 degrees, Figure 8 has strongest peak at 25.395 degrees, Figure 9 has strongest peak at 25.6836 degrees, Figure 10 has strongest peak at 25.5004 degrees, Figure 11 has strongest peak at 25.5112 degrees and Figure 12 has strongest peak at 25.4811 degrees. The SEM images show the morphological structure of the photocatalytic samples.

Ultraviolet- Visible Spectrums (1:3, 1:4) N-TiO_2 Photocatalyst

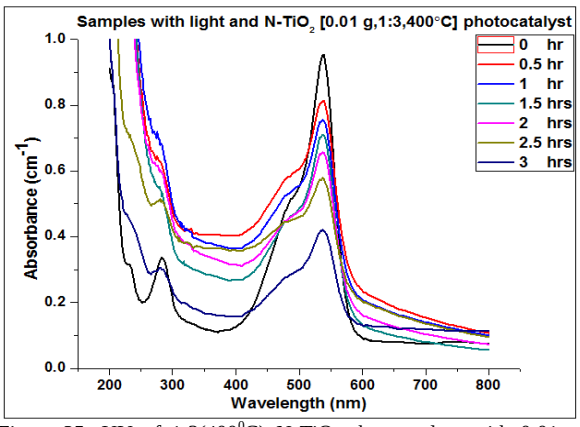

Figure 25: UV of 1:3(400^{0}C) N-TiO_2 photocatalyst with 0.01g conc.

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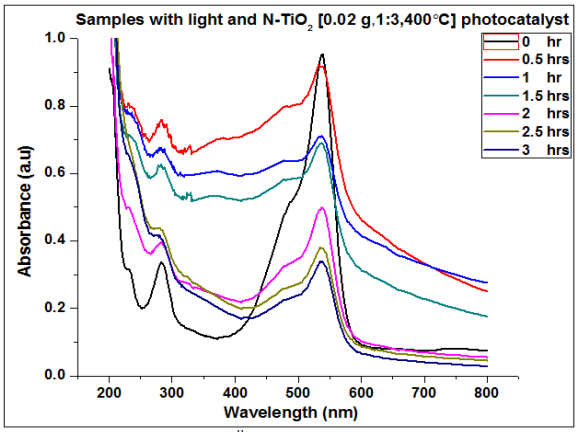

Figure 26: UV of 1:3(400^{0}C) N-TiO_2 photocatalyst with 0.02g conc.

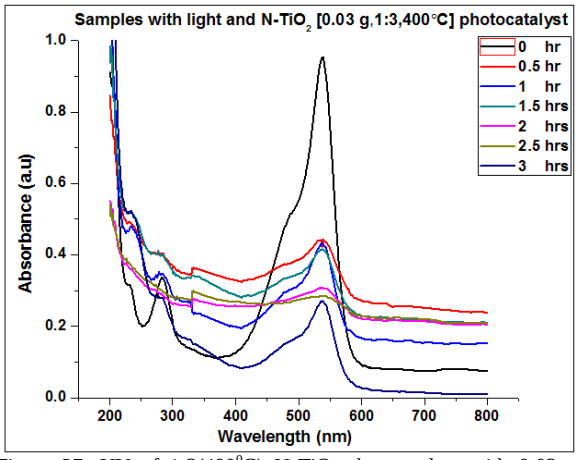

Figure 27: UV of 1:3(400^{0}C) N-TiO_2 photocatalyst with 0.03g conc.

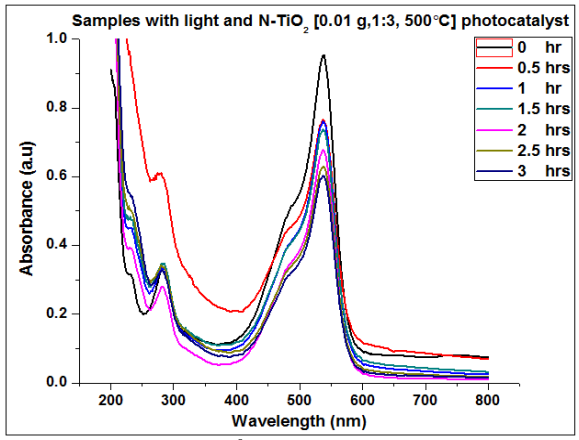

Figure 28: UV of 1:3(500^{0}C) N-TiO_2 photocatalyst with 0.01g conc.

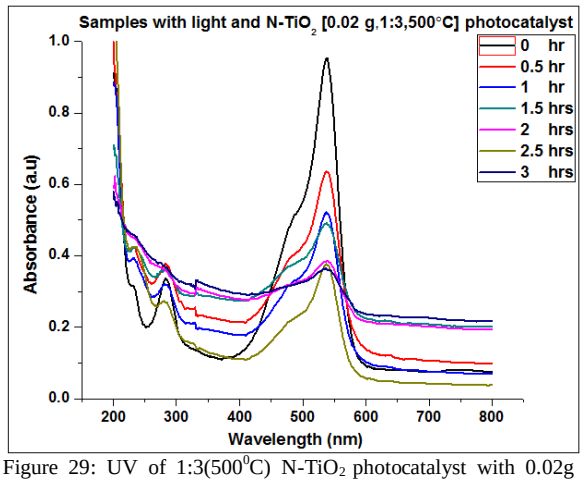

Figure 29: UV of 1:3(500^{0}C) N-TiO_2 photocatalyst with 0.02g conc.

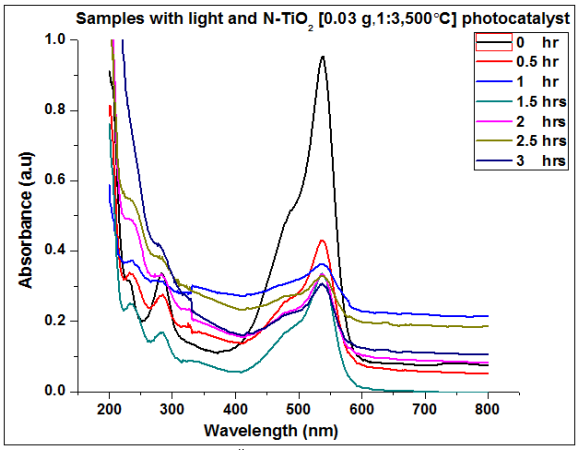

Figure 30: UV of 1:3(500^{0}C) N-TiO_2 photocatalyst with 0.03g conc.

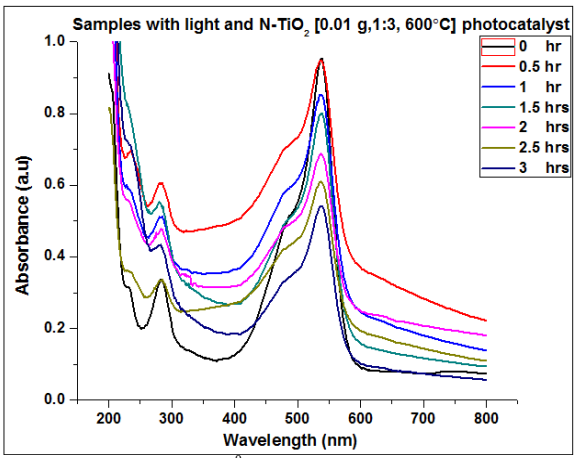

Figure 31: UV of 1:3(600^{0}C) N-TiO_2 photocatalyst with 0.01g conc.

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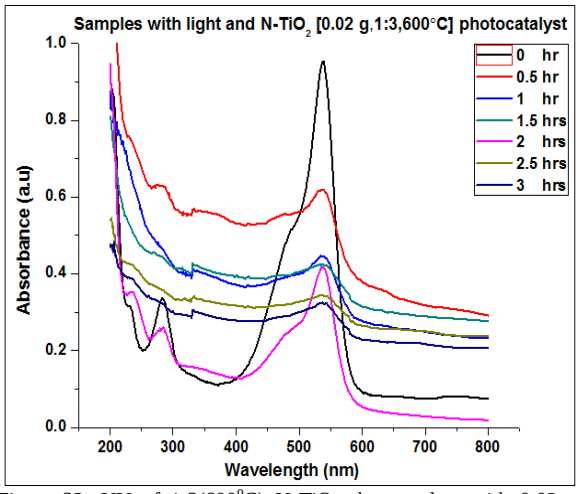

Figure 32: UV of 1:3(600^{0}C) N-TiO_2 photocatalyst with 0.02g conc.

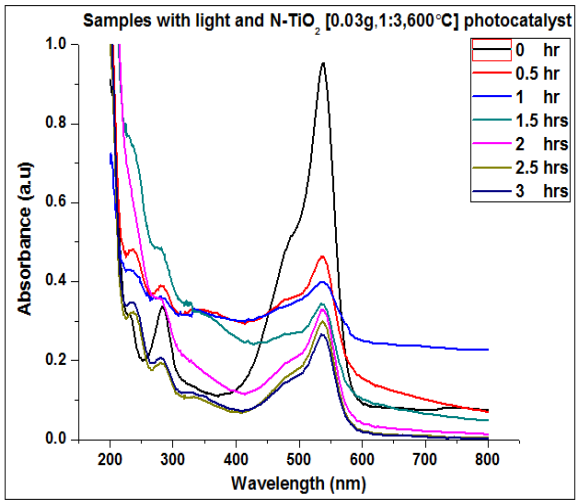

Figure 33: UV of 1:3(600^{0}C) N-TiO_2 photocatalyst with 0.03g conc.

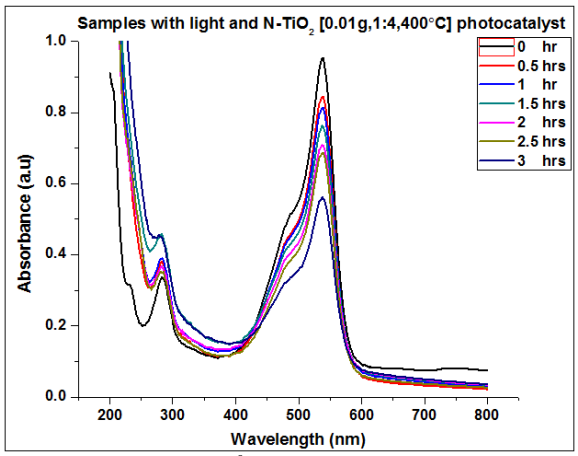

Figure 34: UV of 1:4(400^{0}C) N-TiO_2 photocatalyst with 0.01g conc.

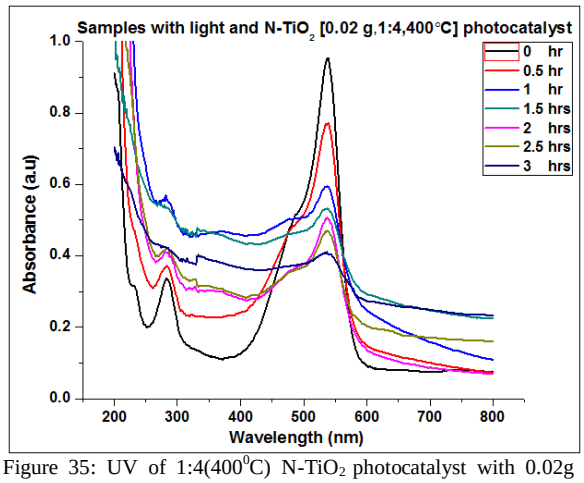

Figure 35: UV of 1:4(400^{0}C) N-TiO_2 photocatalyst with 0.02g conc.

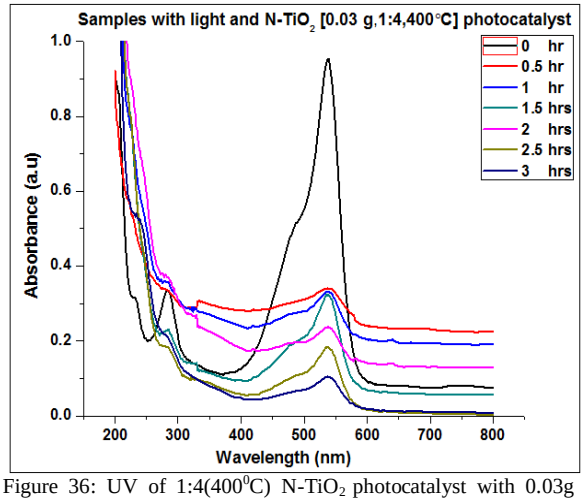

Figure 36: UV of 1:4(400^{0}C) N-TiO_2 photocatalyst with 0.03g conc.

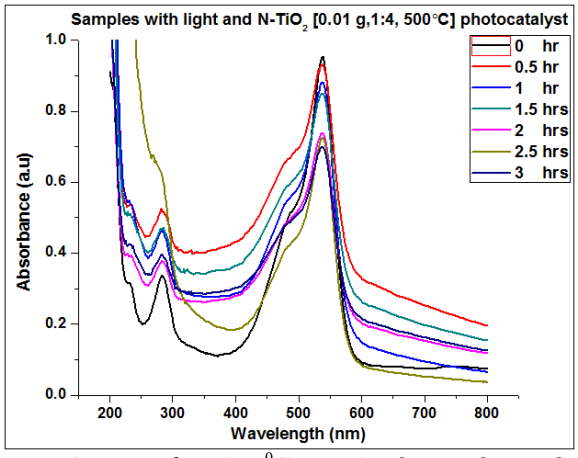

Figure 37: UV of 1:4(500^{0}C) N-TiO_2 photocatalyst with 0.01g conc.

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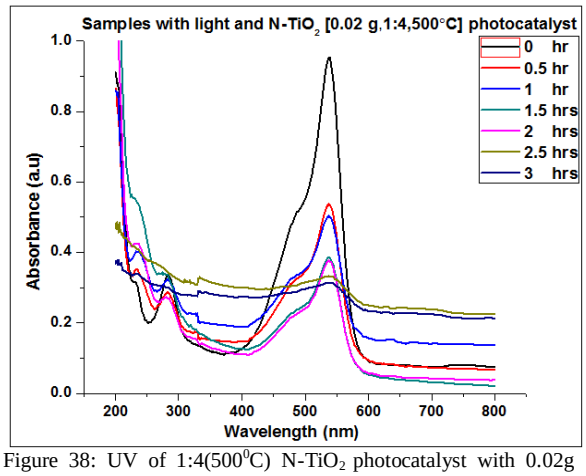

Figure 38: UV of 1:4(500^{0}C) N-TiO_2 photocatalyst with 0.02g conc.

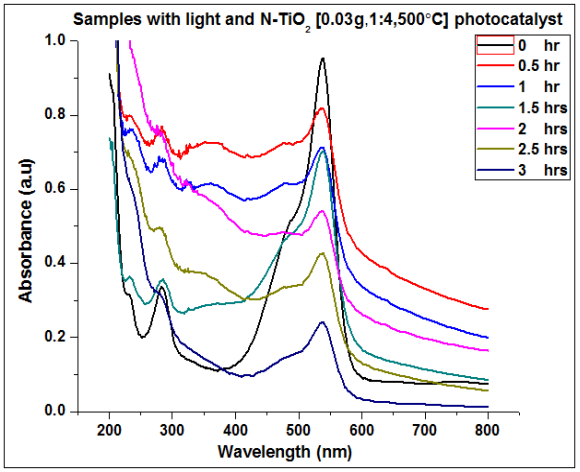

Figure 39: UV of 1:4(500^{0}C) N-TiO_2 photocatalyst with 0.03g conc.

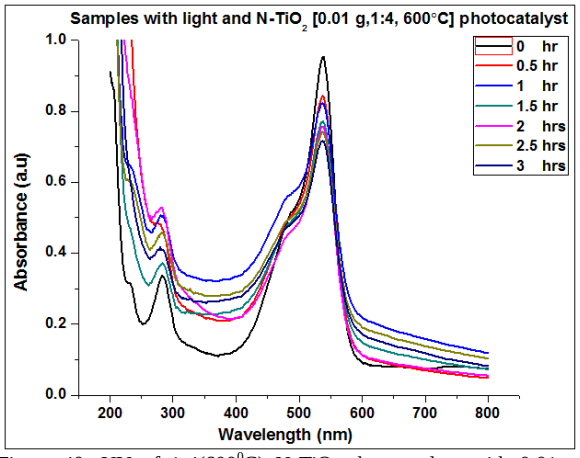

Figure 40: UV of 1:4(600^{0}C) N-TiO_2 photocatalyst with 0.01g conc.

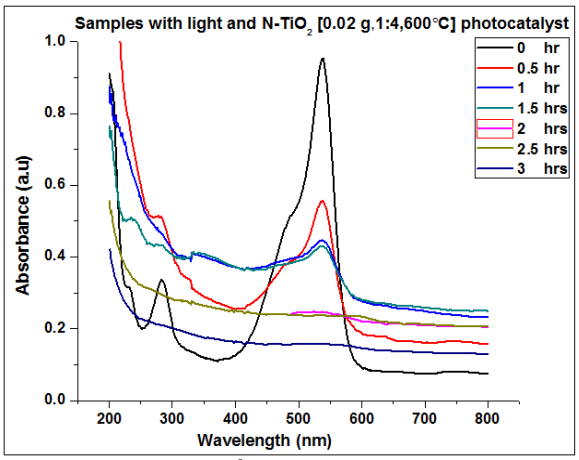

Figure 41: UV of 1:4(600^{0}C) N-TiO_2 photocatalyst with 0.02g conc.

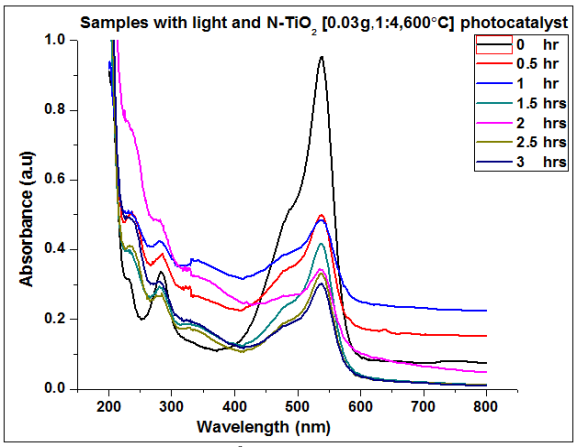

Figure 42: UV of 1:4(600^{0}C) N-TiO_2 photocatalyst with 0.03g conc.

The tabular columns given show the reduction in absorbance rate of the dye degradation.

Table 1: UV values of 1:3(400^{0}C) N-TiO_2 photocatalyst with 0.01g conc.

Time - hrs	Wavelength- nm	Absorbance- a.u
0	537.2	0.953
0.5		0.814
1		0.755
1.5		0.71
2		0.658
2.5		0.579
3		0.421

Table 2: UV values of 1:3(400^{0}C) N-TiO_2 photocatalyst with 0.02g conc.

Time - hrs	Wavelength- nm	Absorbance- a.u
0	537.2	0.953
0.5		0.917
1		0.711
1.5		0.691
2		0.499
2.5		0.379
3		0.338

Table 3: UV values of 1:3(400^{0}C) N-TiO_2 photocatalyst with 0.03g conc.

Time - hrs	Wavelength- nm	Absorbance- a.u
0	537.2	0.953
0.5		0.432
1		0.422
1.5		0.406
2		0.309
2.5		0.286
3		0.271

Table 4: UV values of 1:3(500^{0}C) N-TiO_2 photocatalyst with 0.01g conc.

Time - hrs	Wavelength- nm	Absorbance- a.u
0	537.2	0.953
0.5		0.767
1		0.762
1.5		0.738
2		0.679
2.5		0.63
3		0.603

Table 5: UV values of 1:3(500^{0}C) N-TiO_2 photocatalyst with 0.02g conc.

Time - hrs	Wavelength- nm	Absorbance- a.u
0	537.2	0.953
0.5		0.636
1		0.523
1.5		0.492
2		0.385
2.5		0.377
3		0.365

Table 6: UV values of 1:3(500^{0}C) N-TiO_2 photocatalyst with 0.03g conc.

Time - hrs	Wavelength- nm	Absorbance- a.u
0	537.2	0.953
0.5		0.431
1		0.362
1.5		0.336
2		0.334
2.5		0.329
3		0.307

Table 7: UV values of 1:3(600^{0}C) N-TiO_2 photocatalyst with 0.01g conc.

Time - hrs	Wavelength- nm	Absorbance- a.u
0	537.2	0.953
0.5		0.948
1		0.853
1.5		0.8
2		0.688
2.5		0.611
3		0.542

Table 8: UV values of 1:3(600^{0}C) N-TiO_2 photocatalyst with 0.02g conc.

Time - hrs	Wavelength- nm	Absorbance- a.u
0	537.2	0.953
0.5		0.619
1		0.446
1.5		0.426
2		0.418
2.5		0.345
3		0.325

Table 9: UV values of 1:3(600^{0}C) N-TiO_2 photocatalyst with 0.03g conc.

Time - hrs	Wavelength- nm	Absorbance- a.u
0	537.2	0.953
0.5		0.463
1		0.399
1.5		0.343
2		0.329
2.5		0.299
3		0.265

Table 10: UV values of 1:4(400^{0}C) N-TiO_2 photocatalyst with 0.01g conc.

Time - hrs	Wavelength- nm	Absorbance- a.u
0	537.2	0.953
0.5		0.845
1		0.813
1.5		0.763
2		0.709
2.5		0.687
3		0.562

Table 11: UV values of 1:4(400^{0}C) N-TiO_2 photocatalyst with 0.02g conc.

Time - hrs	Wavelength- nm	Absorbance- a.u
0	537.2	0.953
0.5		0.767
1		0.596
1.5		0.533
2		0.507
2.5		0.47
3		0.411

Table 12: UV values of 1:4(400^{0}C) N-TiO_2 photocatalyst with 0.03g conc.

Time - hrs	Wavelength- nm	Absorbance- a.u
0	537.2	0.953
0.5		0.341
1		0.332
1.5		0.324
2		0.238
2.5		0.184
3		0.105

Table 13: UV values of 1:4(500^{0}C) N-TiO_2 photocatalyst with 0.01g conc.

Time - hrs	Wavelength- nm	Absorbance- a.u
0	537.2	0.953
0.5		0.932
1		0.881
1.5		0.85
2		0.738
2.5		0.726
3		0.7

Table 14: UV values of 1:4(500^{0}C) N-TiO_2 photocatalyst with 0.02g conc.

Time - hrs	Wavelength- nm	Absorbance- a.u
0	537.2	0.953
0.5		0.538
1		0.504
1.5		0.387
2		0.377
2.5		0.333
3		0.314

Table 15: UV values of 1:4(500^{0}C) N-TiO_2 photocatalyst with 0.03g conc.

Time - hrs	Wavelength- nm	Absorbance- a.u
0	537.2	0.953
0.5		0.818
1		0.712
1.5		0.702
2		0.542
2.5		0.427
3		0.241

Table 16: UV values of 1:4(600^{0}C) N-TiO_2 photocatalyst with 0.01g conc.

Time - hrs	Wavelength- nm	Absorbance- a.u
0	537.2	0.953
0.5		0.844
1		0.824
1.5		0.772
2		0.757
2.5		0.743
3		0.717

Table 17: UV values of 1:4(600^{0}C) N-TiO_2 photocatalyst with 0.02g conc.

Time - hrs	Wavelength- nm	Absorbance- a.u
0	537.2	0.953
0.5		0.557
1		0.447
1.5		0.431
2		0.248
2.5		0.239
3		0.159

Table 18: UV values of 1:4(600^{0}C) N-TiO_2 photocatalyst with 0.03g conc.

Time - hrs	Wavelength- nm	Absorbance- a.u
0	537.2	0.953
0.5		0.5
1		0.485
1.5		0.417
2		0.343
2.5		0.332
3		0.303

Table 12 and figure 36 – The samples photodegraded with 0.03g concentration, 1:4, 400^{0}C N-TiO_2 photocatalyst has the maximum efficiency in degradation of the dye from 0.953 to 0.105 absorbance rates.

5. Conclusions

Titanium dioxide always has been a good catalyst and the addition of dopants increases the surface area and helps in effective photodegradation of many dyes.

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