International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN: 0974-4290
Vol.9, No.03 pp 456-461, 2016

Evaluation of new couple Nb_2O_5/Sb_2O_3 oxide for photocatalytic degradation of Orange G dye

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Abstract: This paper involves the study the effect of differences in calcination temperatures on the prepared couple Nb_2O_5/Sb_2O_3 oxide at percentage 1:1 with 400, 500 and 600 °C of calcination temperature and it was characterized by x-ray diffraction. Degradation test of orange G dye was carried out to determine photocatalyst activity for new couple Nb_2O_5/Sb_2O_3 oxide. The photocatalyst experiments were performed at mass of the catalyst (0.05-0.3) g, pH solution in the range (2 -9) and dye concentration 10 ppm were monitored as a function of time at wavelength of 475 nm with recording optical absorbance. The photocatalyst destruction of Orange G dye was found to follow first order kinetics. The results indicate that 0.15 g was the best weight of the catalyst and the best pH for degradation orange G dye was at pH of solution equal to 6.8.
Keywords : Nb_2O_5/Sb_2O_3 oxide, Orange G dye, Degradation, photolysis.

Introduction

Niobium oxide catalyst has received attention in the recent years due to broad industrial application such as solar cell ,optoelectronic technology and catalytic activity[1]. It is used in photo reaction as pure powder or couple with other semiconductor for degradation of organic compounds such as dyes[2-12]. This paper used new couple of Nb_2O_5/Sb_2O_3 that detectors the photo activate by using it for degradation of orange G dye.

Orange G dye is a type of azo dyes and there are commonly used in many filed of industries such as textile , leather, paint , food, cosmetics and pharmaceuticals[13-15]. The are also the are used in biological field by giving various colors between different of the tissues to allow examination under light of microscopy. In recent years have been focused researchers attention heavily on the treatment of dye pollutants because the dye pollutants from industry are main sources for environmental contamination. It is estimated that 1-15% of the dye is lost during dyeing processes found many of new chemical treatment methods called advanced oxidation processes(AOP)[16-18], one of the method is using couple semiconductors as heterogeneous photocatalyst the efficient of chemical oxidation processes for decontamination of drinking water by generation of very reactive free radical such as hydroxyl radical ($OH^{\cdot}$) which can oxidize organic compounds in to solution.

Experimental

Materials

Chemical and materials were used in this work are antimony trioxide Sb_2O_3 purity 98%, supplied by Fluka AG.3-Normal ,Niobium pent oxide Nb_2O_5 has pure 99% supplied by Fluka AG.3-Normal ,and orange G

dye was supplied by sigma-Aldrich has purity more than 90%. NaOH and HCl were purchased from Merck (Germany), structure of orange G dye is given in Figure 1.

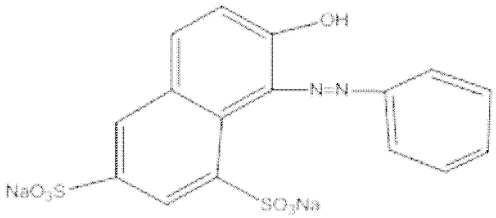

Figure 1: Structure of Orange G dye molecule.

Result and Discussion

The effect of calcination temperatures on the formation of couple Sb_2O_3/Nb_2O_5 at percentage (1:1) with different calcination temperatures (400,500 and 600) °C were investigated by X-ray diffraction as shown in Figure 2 .These results are listed in Table 1. Shows 2ɵ, (d) and average partial size at different calcination temperatures.

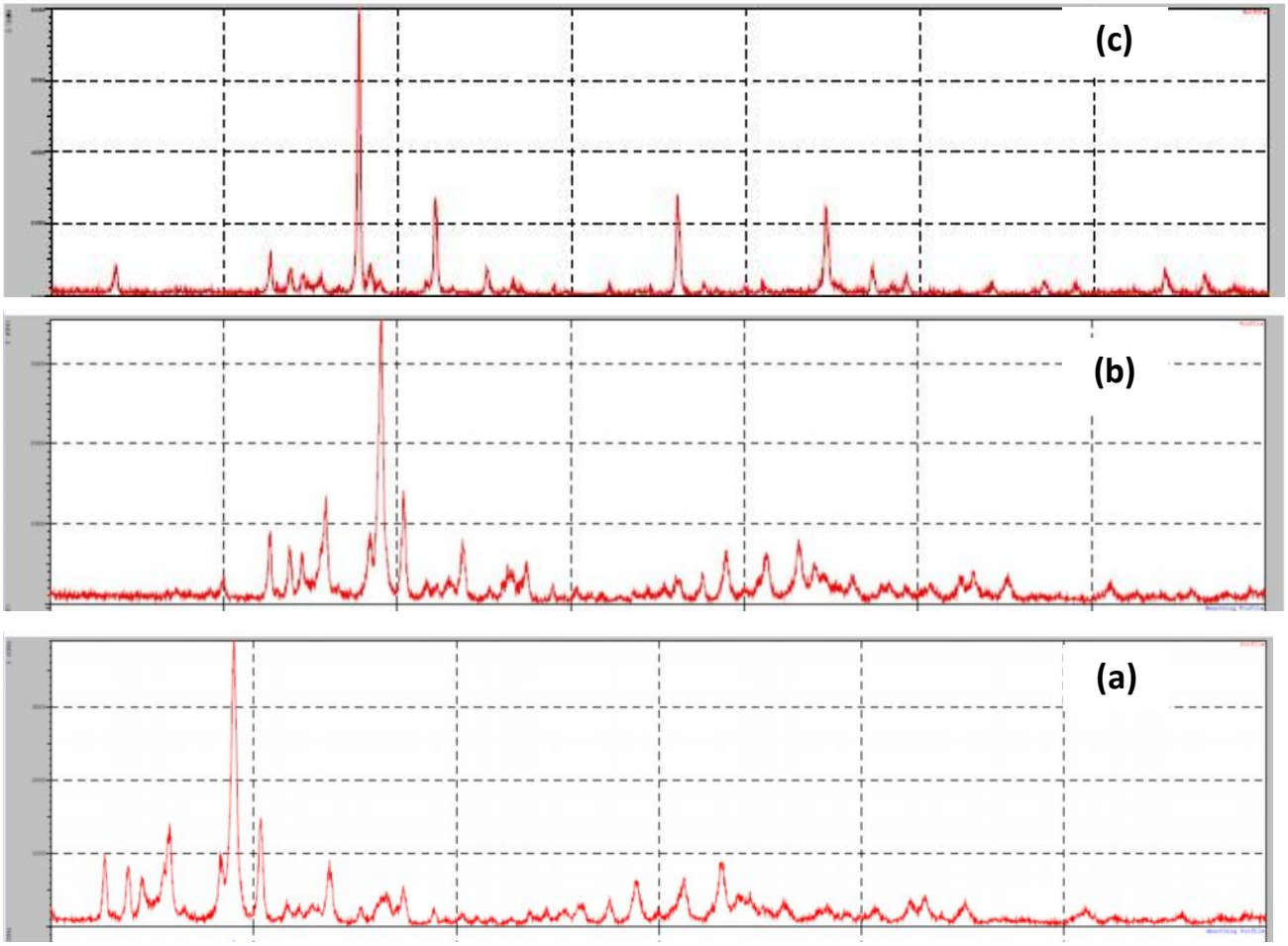

Figure 2: x-ray diffraction for couple of Sb_2O_3/Nb_2O_5 (0.5:0.5) at different calcination temperatures (a. 400 °C ,b. 500 C and c. 600 °C)

Table 1: The effect of different calcination temperatures of the Couple of Sb_2O_3/Nb_2O_5 at (0.5:0.5) on the average partial size.

Average partial size/ nm	FWHM(deg)	2Theta(deg)	d (A)	Temperature/ °C
45.80 42.20 45.95	0.18330 0.18810 0.19440	27.7395 46.0461 54.5780	3.21339 1.96957 1068012	400
26.23 30.15 23.64	0.31300 0.26330 0.34450	29.0675 30.3817 25.8517	3.06953 2.93968 3.44361	500
D =25.40 D = 32.04 D = 23.85	0.32300 0.24790 0.34170	29.0311 30.3607 25.8261	3.07330 2.94167 3.44696	600

Photocatalytic experiments

Effect of the mass couple Nb_2O_5/ sb_2O_3 on the photodegradation of orange G dye.

This factor was studied by using different masses of couple under optimum conditions including the use constant concentration of orange G dye (10ppm), temperature at 298.15 K and normal pH for dye 6.8. The rate constant of photodegradation process increased with weight increase the maximum degradation (86.71%) of the orange G at couple amount 0.15 g. After that weight the percentage of degradation was decreased The rate of photocatalytic was increase with increase the amount of couple this due to increase the active site on the surface of couple Nb_2o_5/sb_2o_3, but increase the amount of couple causes the decrease in the efficiency of photodegradation . At higher values of masses of the used couple this inhibition may be due to successive layers of molecules couple that prevent light from passing through other layer as Figure 3.[11,19,20].

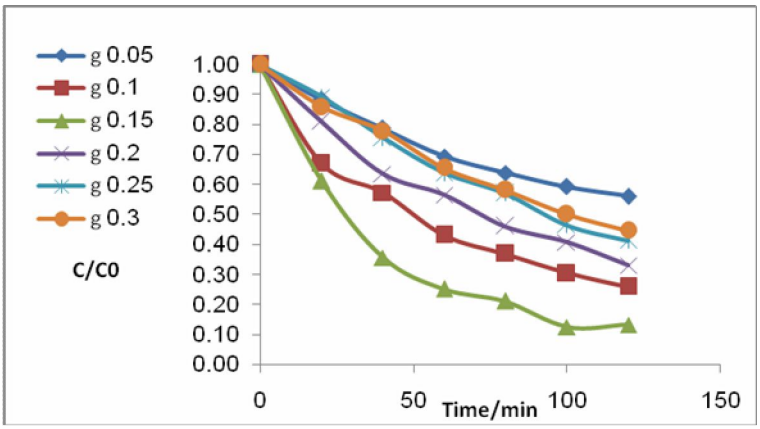

Figure 3:. Effect of the weight of couple Nb_2O_5/Sb_2O_3 on photodegradation of orange G dye.

The results illustrated in Table 2.and plotted in Figure 4. which shows the pseudo first order reaction curve for various weights of couple Nb_2O_5/Sb_2O_3.

Table 2 :Effect of different weights on rate constant.

Weight/gm	k/min
0.05	0.00053
0.1	0.0121
0.15	0.0178
0.2	0.0094
0.25	0.0074
0.3	0.0068

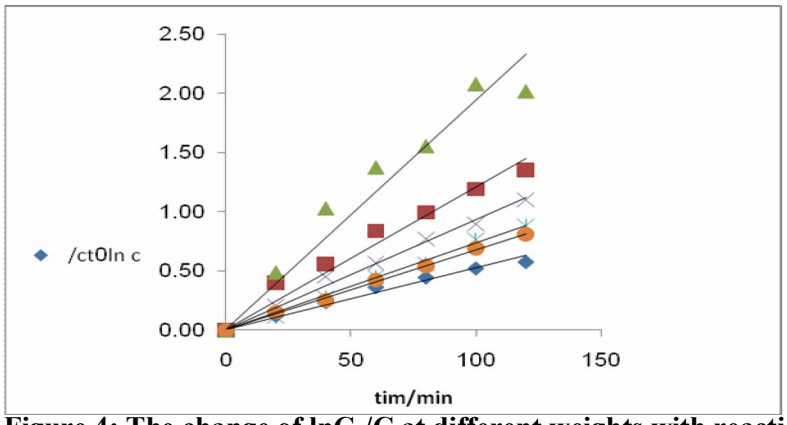

Figure 4: The change of lnC_0/C at different weights with reaction time.

Effect of pH of reaction mixture on dye removal

It is found that many factors influence the effect of pH of reaction mixture on dye removal such as ionization state of the surface , nature of the dye , particle size and ability of molecular adsorbed adsorption on the catalyst surface[21]. the degradation reaction of orange G dye carried out at the pH range between 2-9 at optimum condition 10ppm dye concentration , 0.15 g catalyst amount and temperature equal to 298.15 K. the acid-base of the solution was adjusted by using HCl and NaOH prepare solutions . from measure the absorbance for different pH .It possible can observe the rate constant of different pH value from Table 3.

Table 3:The change of rate constant with different pH value.

pH	$K*10^{-3}min^{-1}$
2.0	5.5
3.0	7.4
5.0	10.1
6.8	19.5
9.0	4.6

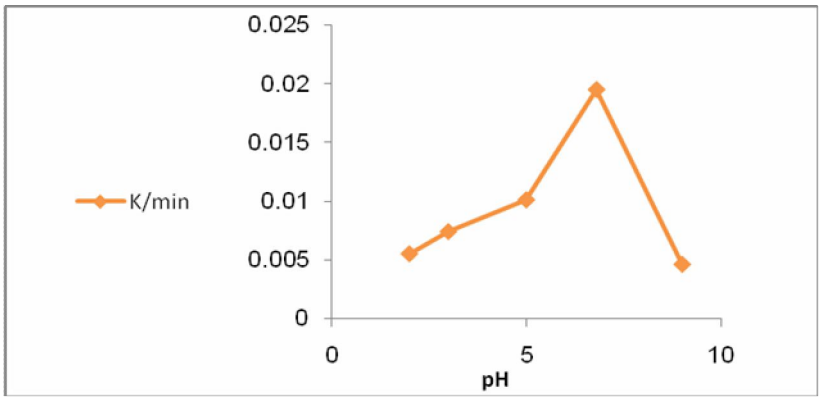

Figure 5: Effect of the pH solution on the rate constant reactions.

From Figure 5. It can be noted that rate constant was increased when the pH increase from 2 to 6.8 after that the rate constant of dye initial down on this behavior similar with literatures[22-26]. The reason for this result the medium of acidic pH solution causes to more H^+ ions are available for the adsorption to mask the surface of the catalyst therefore preventing the photo excitation of catalyst particles , thereby reducing the generation of free radicals .

Conclusion

From the results it was found that at the 1:1 percentage at calcination temperature 600 °C is more active than other calcination temperature. Formation the new couple Nb_2O_5/Sb_2O_3 of semiconductors was investigated by x-ray diffraction patterns. The ability for photodegradation of orange G dye 86.74% in the optimum condition amount of couple 0.15 g, concentration dye 10 ppm, temperature 298.15 K and normal pH 6.8 of dye solution.

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