Study the efficiency of thermal conversion of some organic dyes in aqueous solutions

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Abstract

A study has been preformed to investigate the photoconversion of eosin B , brilliant yellow and thymol blue dyes in aqueous solution by exposing the dye solution to solar radiation at a limited period of time. The efficiency was invistigated by measuring the difference between maximum temperature of dye solution and reference (water). The work involves the studying of the effect of dye concentration , time of exposure and presence of EDTA as electronic donor . It has been found that the efficiency was partially depending on the cocentration of dye , while the conc . was decreasing throuh the time of exposure . When the EDTA was added, on clear positive effect was found except the brilliant yellow and thymal blue with concentration of $1x10^{-4}$ M. The optimum concentration of most states was $1x10^{-3}$ M.

Introduction

The use of organic dyes in the photoconversion of sun light witnessed huge expansion throuh the last two decades . This process needed essential requirements such high solubility of dye in low cost solvents, high absobance of wide range of visible spectrum , stability of dye toward light and heat and availability of dye.

The liquid solar collector system(LSCS) has been designed and tested in previous studies[-3] .The method of these studies concentrated on using the dye in mixture or individual state. The efficiency of LSCS has been measured using figure of merit (FM) which is defined as[1]:

$$F.M=\frac{\Delta T_{MAX}}{\bar{I}\,t_{\Delta TMAX}}$$

Where ΔT_{MAX} is the difference between maximum temperature of dye solution and temperature of reference solution, $T_{\Delta TMAX}$ the required time of arrival ΔT_{MAX}, $\bar{I}$ is the average of intensity of sun light in this period of time. The scope of present work deals with testing the thermal performance of eosin B, brilliant yellow and thymol and blue dyes. The work around about the studying of effect of dyes concentration and effect of EDTA which is mentioned in literature as donor of electrons[4-7]. EDTA has a virtue of reduction of oxidized form of dye molecules in solution.

Experimental

All materials obtained in this work were used as received. Eosin B was supplied by Eastman, thymol blue and brilliant yellow were received from BDH, and EDTA was supplied by Fluka.

Pyrex flasks of 1 liter have been used to prepare of dye solutions in the range $1x10^{-3}$ M $-1x10^{-4}$ M by dissolving the dye powder in to water with stirring and slight heating to complete the dissolving . The same solutions again were prepared with adding the EDTA ($1x10^{-4}$ M), then all vessel were exposed to direct sun light . Temperatures were measured using Bekman thermometer. The intensity of sun light has been measured using solar meter supplied by pannel . The absorbance of dyes was measured using Shemadzu UV –120 spectrophotometer.

Results and Discussion

All dyes obtained in the present work have acceptable solubility in water and the colors of their aqueous solution ($1x10^{-3}$ – $1x10^{-4}$ M) are clear. Table(1) shows the spectral data of dyes .. These data indicate accceptable absorbance of there dyes in visible region.

The change of FM values of dyes with are illustrated in figures (1-6). Table (2) shows the change of the maximum FM with concentration of dyes. These data indicate that the dyes gave low FM values in solution of $1x10^{-4}$ M which related to low number of excited molecules in comparison with solutions of higher concentrations . Table (2) provides important information about acceptable stability of these dyes through the time of testing. Fig(1-6) illustrate that the FM values depends on the factors as concentration, time of exposure and intensity of sun light. It is clear that the FM values are changed in random state which may be due to the extreme difference of heat of visible spectrum through the studying period. All maximum values have been found nearby the mid time of irradiation . The highest values of FM were obtained with brilliant yellow which is attributed to stability and acceptable absorbance of this dye.

The adding of EDTA ($1x10^{-4}$M) to the same solutions at the same period of time causes an increase of FM value with brilliant yellow and thymol blue dyes in concentration of $1x10^{-4}$M. Which may be dye to reduction of oxidized form of dye and hence increasing the absorbance of dye molecules.

Fig(7) shows a change of dye absorbance ($1x10^{-4}$M) with time of exposure to sun light. It is clear that the degradation of dyes increase with time a result of conversion of absorbing species of dye to non absorbing form by oxidation the molecules or conversion this species to another forms such as dimerization of dye molecules[4] and aggregates of dye molecules[8] which lead to reduce dye absorbance.

Table (1): λ max and range of absorbption of dyes.

NO	Dye	Range of absorption, nm	λ max,nm	Color of solution
1.	Eosin B	460 –550	514	Orange
2.	Brilliant Yellow	350 –460	397	Red -Yellow
3.	Thymol Blue	470 –600	594	Brown

Table (2): Max value of FM relation to concentration of dyes in absance and present of EDTA ($1x10^{-4}$M).

NO	Dye	$FMx10^3$				
		$1x10^{-3}$ M	$0.5x10^{-3}$M	$0.25*x10^{-3}$M	$0.125*x10^{-3}$M	$1x10^{-4}$M
1.	Eosin	5.2	4.6	3.2	2.6	2.8
2.	Eosin B+ EDTA	4.6	4.4	3.4	3.0	3.1
3.	Brilliant Yellow+EDTA	6.2	5.0	7.5	2.0	1.6
4.	Brilliant Yellow+EDTA	3.8	3.2	3.3	3.3	2.5
5.	Thymol blue	5.3	3.5	1.6	1.5	1.6
6.	Thymol blue+EDTA	1.9	1.4	1.6	1.8	1.3

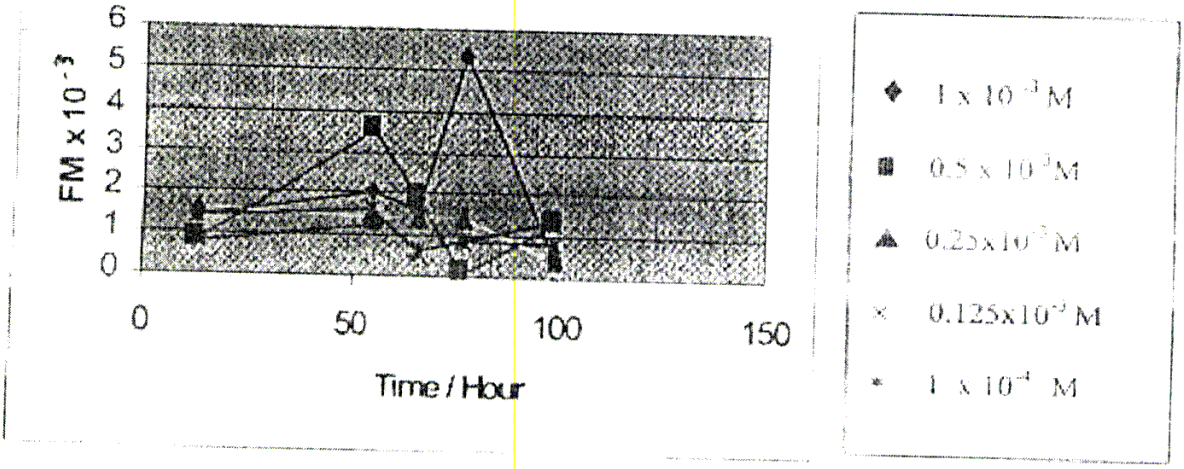

Fig (1) :- Relation of FM Value With Time of Exposure to Sun Light for Aqueous Solution of Thymol Blue in Different Concentration.

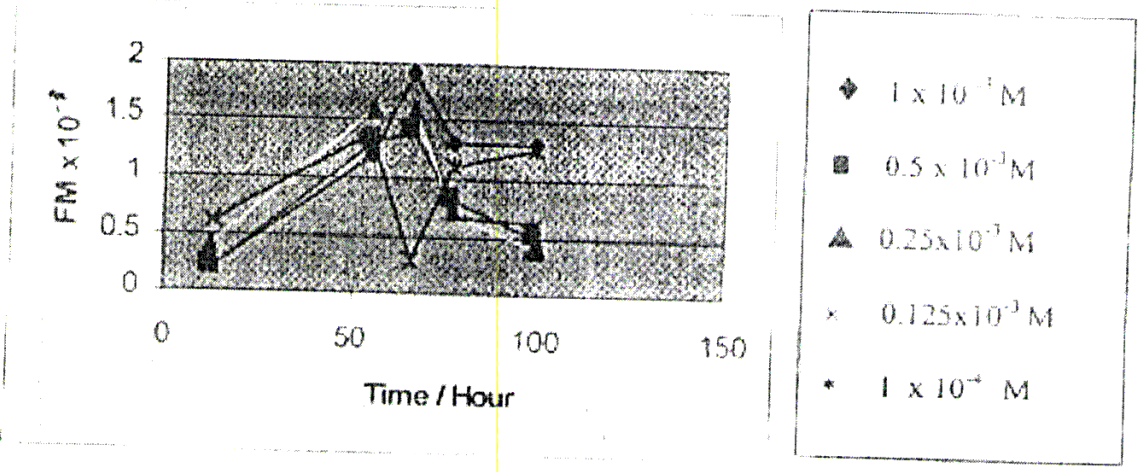

Fig (2) :- Relation of FM Value With Time of Exposure to Sun Light for Aqueous Solution of Thymol Blue in Different Concentration and Presence of EDTA (1 x 10^{-4} M)

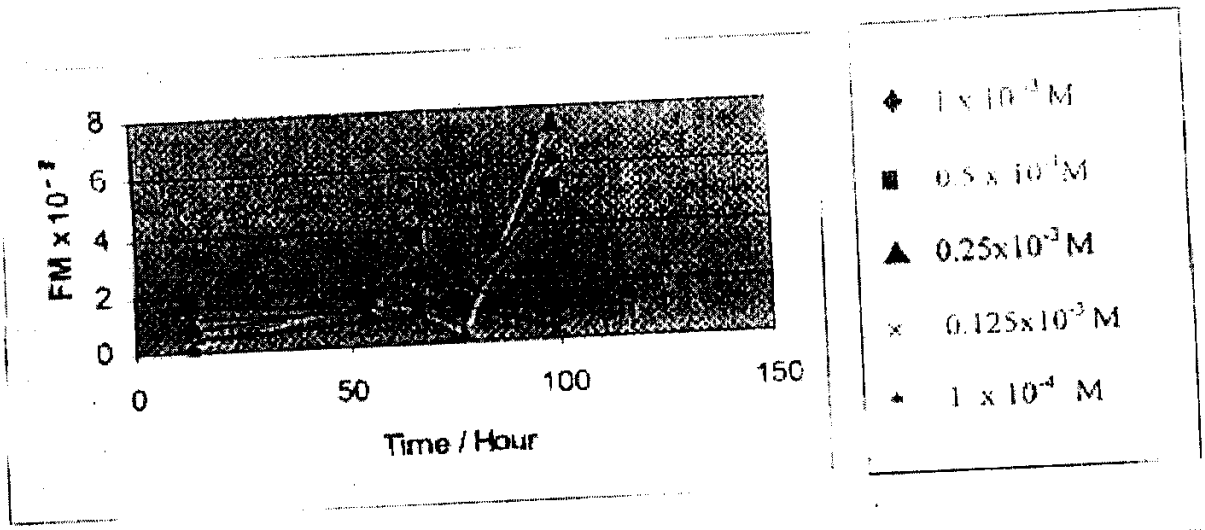

Fig (3) :- Relation of FM Value With Time of Exposure to Sun Light for Aqueous Solution of Brilliant Yellow in Different Concentration .

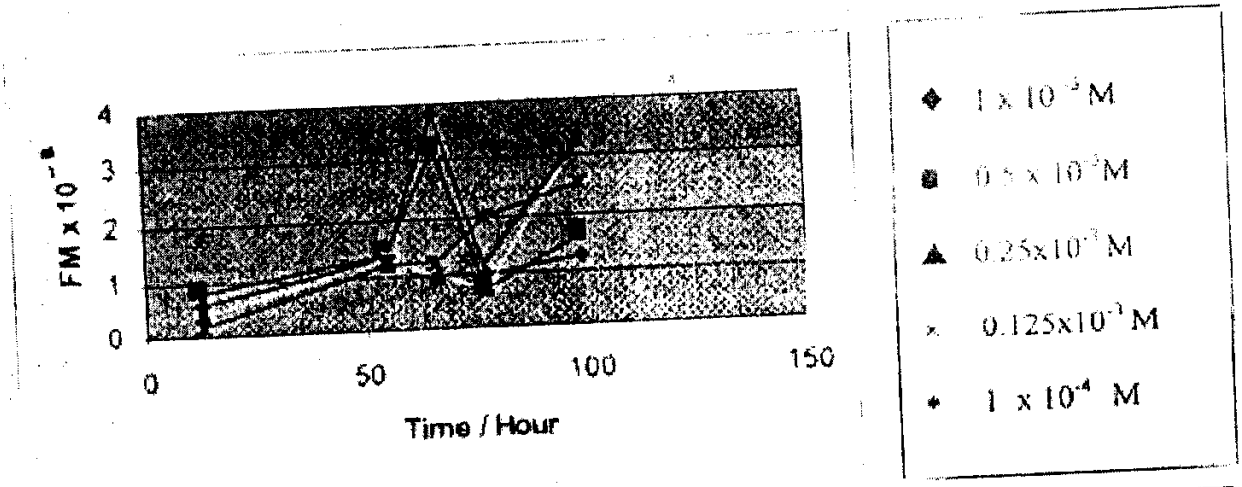

Fig (4) :- Relation of FM Value With Time of Exposure to Sun Light for Aqueous Solution of Brilliant Yellow in Different Concentration and Presence of EDTA (1×10^{-4} M)

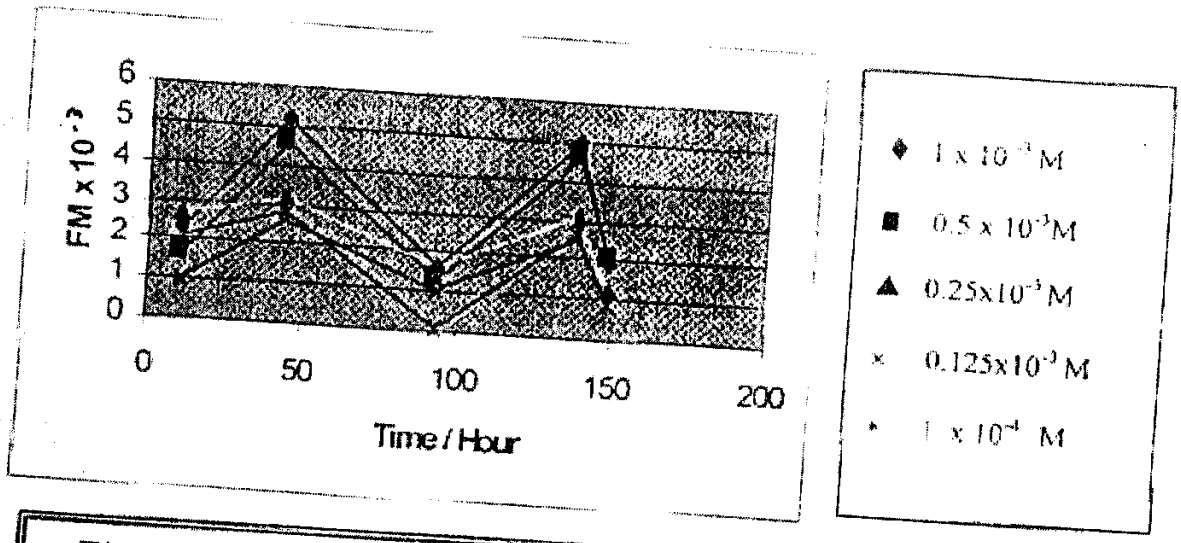

Fig (5) :- Relation of FM Value With Time of Exposure to Sun Light for Aqueous Solution of Eosin B in Different Concentration .

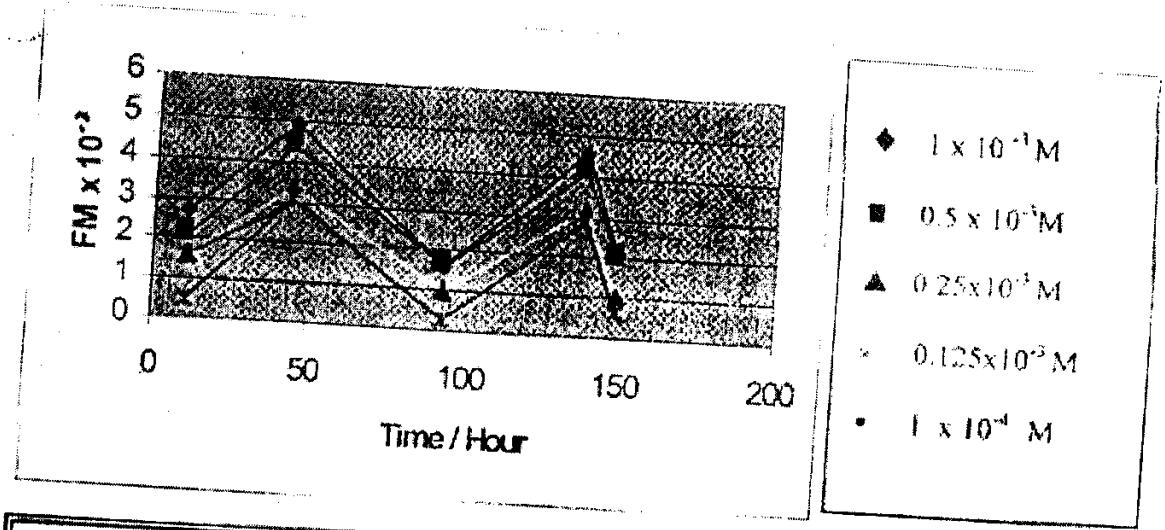

Fig (6) :- Relation of FM Value With Time of Exposure to Sun Light for Aqueous Solution of Eosin B in Different Concentration and Presence of EDTA (1 x 10^{-4} M)

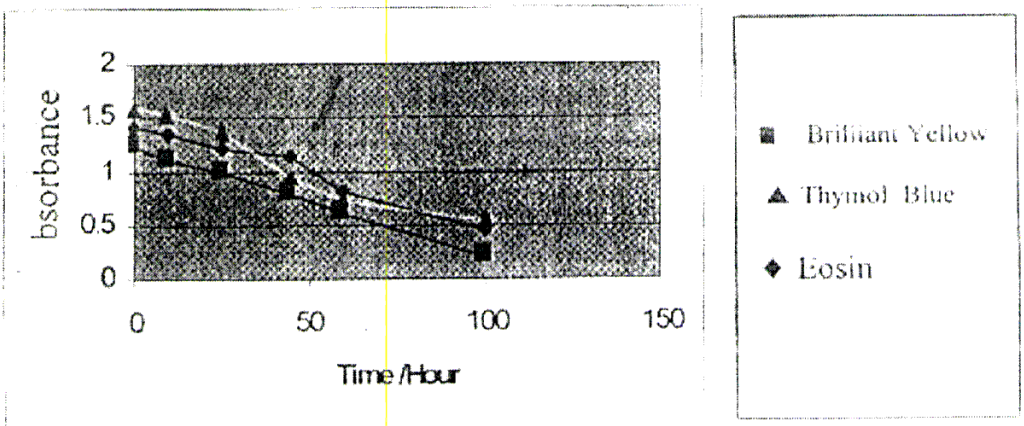

Fig (7) :- Relation of Absorbance with Time of Exposure to Sun Light for Eosin B , Brilliant Yellow , and Thymol Blue Dyes (1×10^{-4} M).

دراسة كفاءة التحويل الحراري لبعض الاصباغ العضوية في محاليلها المائية

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الخلاصة

تم اجراء دراسة لمقارنة كفاءة تحويل ضوء الشمس الى حرارة لاصباغ في في محاليلها المائية بوساطة Eosin B, Brilliant Yellaw, Thymol Blul تعريض محاليل الاصباغ لضوء الشمس المباشر لفترة زمنية محددة حيث تم فحص الكفاءة بوساطة قياس الفرق بين درجة الحرارة العظمى لمحلول الصبغة ودرجة حرارة المرجع (الماء) وتم دراسة تأثير تركيز الصبغة والفترة الزمنية واضافة EDTA كمانح للالكترونات Donor of Electrons على كفاءة التحويل الحراري . وجد بصورة عامة ان كفاءة التحويل تعتمد بصورة جزئية على التركيز عند استمرار فترة التعرض وارتبط ذلك مع انخفاض تركيز الاصباغ لنفس الفتره، ولم يحصل تاثير ايجابي عند اضافه EDTA بتركيز ١٠X١٠$^{-4}$ مولاري الا في حاله صبغتي Thymol Blue,Brilliant Yellow بتركيز ١٠ x ١٠$^{-4}$ مولاري . ووجد ان التركيز الامثل لمعظم الحالات هو 1 x 10^{-4} مولاري .