USE OF PHOTOCATALYST (S) AND OTHER TECHNOLOGIES FOR GENERATING NON-CONVENTIONAL AND REPRODUCIBLE RESOURCES OF CLEAN ENERGY

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Abstract – The never exhausting demands for energy by human population across the world for diverse purposes have stimulated research to find resources of clean energy which is sustainable and reproducible [recyclically]. Initiatives have been taken to harness solar radiations, wind velocity, intensity of tidal waves, and disposal of garbage as source of energy. Fossil fuels are no longer considered safe as coal, wood, petro- products argument pollution that is causing increased CO₂ emission. This is now defined and confirmed as cause of global climatic change with disastrous effects. Our studies on the use of Toluidine Blue (TB) as photo-catalyst to generate energy (H₂) has shown promise of its possible use on a large scale as energy nucleus in chemical plants with appropriate substrates. At least six systems were tested and evolved by using TB. These are TB- EDTA system, TB- HEDTA system, TB-Succinic Acid system, TB- Glutaric Acid system, TB-Glucose system and TB-Mannitol system. These exhibited varying degrees of efficiencies under experimental condition. It is suggested that search should continue for various molecular species / mimics whose kinetics of reaction is very high. This would result in greater turn over of H₂ Use of H₂ as a clean source of energy is now globally accepted. Its industrial application in automobile is being successfully tested. It can be foreseen that this energy can be used in railways, aeronautics, ships. Solar energy generating plants can use these photo-catalysts. These plants when installed in hospitals, schools, colleges, universities, residential areas etc. will provide low cost energy. This will save revenue which can be used for development. Similarly wind velocity, tidal waves, garbage, can generate energy. The by product of latter generate fertilizers, that can be used in agriculture.

KEY WORDS: Photo catalyst, non-conventional and reproducible, technologies, clean energy.

I. INTRODUCTION:
The search for clean energy has led to finding a variety of photo-catalysts and substrates that can release hydrogen. Several by-products also result from reaction between the dye and the substrate. Photo-catalytic effects of o-toluidine have been used by Pargoletti et al.[2017][1]. It was found by: - J Yao, C Wang (2010)[2] that visible light is used for photo-catalytic degradation of toluidine blue-o. Methylene blue and Cango Red are some of the azo dyes whose potential role as photo-catalytic substance have been studied by Arafa and Matter (2017)[3]. There has been a considerable research on a variety of photo-catalysts for enhancement degradation. This has been considered as an efficient procedure for waste water treatment as well by Mosleh et al. (2017)[4]. Various strategies have been used to make visible light responsive photo-catalysts involving metals and non-metals, Sharotri and Sud (2017) [5]. Some other variables for enhancing photo-catalytic activity are pH, intensity of light, substrate concentration and temperature in addition to dye concentration.
The survey of literature shows that photo-catalytic degradation of azo dyes and others can be a useful method to use solar energy as a source of clean and non-polluting fuel for use in diverse industrial endeavors and for domestic purposes.

OBJECTIVES:
The purpose of the present study was to examine the photo-catalytic degradation of Toluidine Blue in aqueous solution and in various concentrations using pH, temperature, intensity of light and variety of substrates as – EDTA, HEDTA, Succinic Acid, Glutaric Acid, Glucose and Mannitol.
This was done to understand the kinetics of electron transfer between substrate and dye as well.

MATERIAL AND METHODS:
A homogeneous mixture of dye and reductant solution was exposed to light source. A water cell was used in between the reaction vessel and light source to cut off the thermal radiation. Irradiation was provided by a 200 W Tungsten Lamp. Optical density and light intensity was measured by Solarimeter and UV visible spectrophotometer. pH variants were also used. Time periods of exposure were another variable.

The decrease in optical density (O.D.) was taken as indicator of bleaching of dye during the photo-catalytic process. The different substrates used in the study as stated above were examined under different pH, light intensity, concentrations. Dye concentration was also a variable.
TABLE
Photo-catalytic activity of Toluidine Blue and Different Substrates

<table>
<thead>
<tr>
<th>Substrates</th>
<th>Effect of pH</th>
<th>Dye concentration M x 10^{-5}</th>
<th>Substrate concentration M x 10^{-3}</th>
<th>Light Intensity 4.0 mWcm^{-2}</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDTA</td>
<td>7.5 – 11.5</td>
<td>1.25 - 3.50</td>
<td>1.25 – 3.50</td>
<td>6.0 – 44.0</td>
</tr>
<tr>
<td>HEDTA</td>
<td>7.5 – 11.5</td>
<td>1.25 - 3.50</td>
<td>1.25 – 3.50</td>
<td>6.0 – 44.0</td>
</tr>
<tr>
<td>SUCCINIC ACID</td>
<td>7.5 – 12.0</td>
<td>1.25 - 3.50</td>
<td>1.25 – 3.50</td>
<td>6.0 – 44.0</td>
</tr>
<tr>
<td>GLUTARIC ACID</td>
<td>7.5 – 12.0</td>
<td>1.25 - 3.50</td>
<td>1.25 – 3.50</td>
<td>6.0 – 44.0</td>
</tr>
<tr>
<td>GLUCOSE</td>
<td>7.5 – 11.5</td>
<td>1.25 - 3.50</td>
<td>1.25 – 3.50</td>
<td>6.0 – 44.0</td>
</tr>
<tr>
<td>MANNITOL</td>
<td>7.5 – 12.0</td>
<td>1.25 - 3.50</td>
<td>1.0 – 3.00</td>
<td>6.0 – 44.0</td>
</tr>
</tbody>
</table>

MECHANISM

On the basis of these observations, a tentative mechanism for photocatalytic degradation of Toluidine blue dye has been proposed as follows:

\[
^1TB_0 \xrightarrow{\text{hv}} ^1TB_1 \quad \ldots(1)
\]

\[
^1TB_1 \xrightarrow{\text{ISC}} ^3TB_1 \quad \ldots(2)
\]

SC \rightarrow e^- (CB) + h^+ (VB) or SC^*

\ldots(3)

\[
e^- + O_2 (\text{Dissolved oxygen}) \rightarrow O_2^* \quad \ldots(4)
\]

\[
^3TB_1 + O_2^* \rightarrow \text{Leuco TB} \quad \ldots(5)
\]

\[
\text{Leuco TB} + O_2 \rightarrow \text{Products} \quad \ldots(6)
\]

Toluidine blue (TB) absorbs radiations of suitable wavelength and it is excited giving its first excited singlet state followed by intersystem crossing (ISC) to give its more stable triplet state. Along with this, the semiconductor also utilizes this energy to excite its electron from valence band to the conduction band. The electron in conduction band is abstracted by dissolved oxygen to generate O_2 which will convert.
Fig 1: DYE – EDTA SYSTEM –

(a)  (b)  (c)  (d)  (e)

Fig 1 – From a to e show a typical run, effect of - pH, Dye concentration, EDTA concentration and Light intensity.
Fig 2: DYE – HEDTA SYSTEM –

(a)  
(b)  
(c)  
(d)  
(e)  

Fig 2 - From a to e show typical run, effect of - pH, Dye concentration, HEDTA concentration and Light intensity.
Fig 3: DYE – SUCCINIC ACID SYSTEM –

(a) (b) (c) (d) (e)

Fig 3 – From a to e show a typical run, effect of - pH, dye concentration, Succinic Acid concentration and Light Intensity.
Fig 4: DYE – GLUTARIC ACID SYSTEM –

(a)  
(b)  
(c)  
(d)  
(e)  

Fig 4 – From a to e show a typical run, effect of – pH, Dye concentration, Glutaric Acid concentration and Light Intensity.
Fig 5: DYE – GLUCOSE SYSTEM

(a) 
(b) 
(c) 
(d) 
(e) 

Fig 5 – From a to e show a typical run, effect of – pH, Dye concentration, Glucose concentration and Light Intensity.
DISCUSSION

The result of the present study show that different substrates under varying experimental conditions exhibit different rate of reactions and consequently bleaching of dye. The most effective substrate for Toluidine Blue was found to be Mannitol.

A comparison of these results indicates several interesting co-relations as well as differences. Thus Fasciani et al. (2010)[6] found that the change of color during excitation persists only for few mili seconds while Banerjee et al. (2010)[7] found that Methylene Blue and Toluidine Blue because of their larger variety of surface are more effective. Llorente et al. (2015)[8] studied the photo induced degradation of Toluidine Blue assisted by NPTiO$_2$. They found that TiO$_2$ photo-catalytic degradations of azo dyes and aqueous solution show differential kinetics. On the other hand Abazari (2014)[9] found that the concentration of Toluidine Blue-o was decreased due to photo degradation of the dye. It is interesting to add that visible light induced photo-catalytic degradation of Toluidine Blue Wan (2010). This result is somewhat similar to our observations.

Satpura et al. (2017)[10] found that pH condition did not significantly influence the photo-degradation of Methylene Blue. This is not an agreement with our work. It
is proposed that more photo-catalytic substances be found for use in release of energy on commercial scale. This suggestion is in confirmatory to lab to land program of government of India.

REFERENCES


