The use of light in chemistry has aroused much attention during the last two three decades. The reason for this is that semiconductor catalysis in the presence of light can have the ability to clean the environment in a sustainable manner which has a minimal environmental impact. Photocatalysis in organic synthesis concerns the use of light to induce chemical transformations onto organic substrates which are transparent in the wavelength range employed. There are actually two methods for the removal of pollutants from the ecosystem. Complete mineralization is the one way to remove the pollutants. Conversion of toxic compounds to other compounds having toxicity less than the initial starting compound is the second way. In this chapter, we are concentrating on the second aspect and discuss the photo-oxidation of some polycyclic aromatic hydrocarbons by using metal, non-metal modified TiO₂ systems.

5.1. Introduction

Heterogeneous photocatalysis in selective organic synthesis is not frequently employed although nowadays the demands for replacement of
traditional oxidation methods with cleaner ones are increasing [1]. Photo-
oxidation can be considered as one of the important classes of 
photocatalytic reactions responsible for the conversion of organic 
substrates in a greener and cost effective way. Irradiation of a suspension 
containing semiconductor powder, mostly of the inexpensive and 
environmentally benign TiO\textsubscript{2} is an effective method for the oxidation of 
organic substrates [1-6]. These kinds of heterogeneous photocatalytic 
reactions are possible in both aqueous and non-aqueous medium [7-11]. 
Mineralization of organic pollutants using TiO\textsubscript{2} is a well-known area but 
studies on photo induced organic transformation based on TiO\textsubscript{2} are 
comparatively rare. Every organic functional group containing either a 
non-bonded lone pair of any $\pi$ conjugation can be activated towards TiO\textsubscript{2} 
photocatalyzed oxidative reactivity [12]. TiO\textsubscript{2}-sensitized organic 
photosynthetic reactions include oxidation and oxidative cleavage, 
reduction, isomerization, substitution and polymerization. Oxidatively 
inert solvents provide suitable medium for these kinds of reactions [14]. 
The C-H bond activation is one of the most challenging chemical 
problems and also has a lot of practical applications. Generally, the 
formation of oxidation products depends mainly on the reaction medium 
[15]. Conversion of 1-decene and 2-hexene to their corresponding 
carbonyls and epoxides by irradiated photocatalyst has been reported 
[16,17]. The selectivity of the epoxidation reaction in a mixture of 
acetonitrile and butyronitrile was improved using rutile (instead of 
anatase) and visible light [18]. Hydrogenation of propyne to propene by 
noble metals -loaded TiO\textsubscript{2} was reported, of which Pd/TiO\textsubscript{2} presents the 
highest photocatalytic activity [19]. Photo-oxidation of cyclohexane to 
cyclohexanol and cyclohexanone has also been reported in the liquid
phase at room temperature and atmospheric pressure [20-22]. Due to the stability of aromatic nucleus, photocatalytic reactions occur in aqueous solutions and especially facilitate various side chain reactions. The reaction rate is sensitive to ring substitution. The electron-donating groups enhance and electron-withdrawing groups decrease the rate of the reaction [23]. This type of reactions may present a convenient method for the oxidation of benzene ring substituents.

The photo-oxidation of toluene leads to benzaldehyde and subsequently to benzoic acid in MeCN which is accelerated by the presence of small amounts of H$_2$SO$_4$ [24]. It is assumed that the HSO$_4^-$ anions promote the reaction by mediating the oxidation of the organic substrate by reacting with the photogenerated hole to form highly oxidizing HSO$_4$ radicals. They also suggested that the formation of benzoic acid is favoured by stronger electron-withdrawing substituents. The reaction scheme is shown in Fig. 5.1.

![Fig.5.1. Reaction Scheme for the Photo-oxidation of Substituted Toluene](image)

Another study revealed that the oxidation rate of the alkyl chain of alkylbenzenes in UV-irradiated acetonitrile solutions decreases with the number of carbon atoms and carbon atom in the ‘α’ position with respect to the aromatic ring is more reactive [25]. 2-formylcinnamaldehyde was formed from Naphthalene in a mixed solution of water and MeCN.
Chapter 5

The best selectivity of 85% and the highest reaction rate were obtained using a photocatalyst containing 90% rutile and 10% anatase [26]. Photocatalytic oxidation of methylpyridines (picoline) in acetonitrile leads to inorganic products due to the poor stability of pyridine nucleus compared to benzene nucleus [5]. Selective oxidation of alcohols to carbonyls is one of the most important chemical transformations in industrial chemistry and these carbonyl compounds such as ketones and aldehydes are precursors for many drugs, vitamins and fragrances and are important intermediates in many complex syntheses [27,28]. Most of reactions use toxic, corrosive or require expensive oxidants and drastic conditions such as high pressure, temperature or strong mineral acids [29,30]. But photocatalysis is an effective and easy way for the preparation of these industrially important compounds. Photo-oxidation of Benzhydrol to Benzophenone over TiO$_2$ modified with Lanthana was also reported [31]. Aldehydes, ketones, acids and amines are also converted to specific products by using semiconductor mediated photocatalysis [32-34]. It is also applicable in the synthesis of heterocyclic compounds [35]. In this chapter we are concentrating on the photo-oxidation of some substituted anthracene derivatives.

Polycyclic aromatic hydrocarbons (PAHs), also known as poly-aromatic hydrocarbons or polynuclear aromatic hydrocarbons, are fused aromatic rings and do not contain hetero-atoms or substituents [36]. These are found naturally and also formed by the incomplete combustion of oil, garbage etc. These are one of the structural constituents of dyes, plastics and pesticides. Effluents from coir and textile industries contain anthracene based PAHs which results in the contamination of drinking
Photo – oxidation of Some Polycyclic Aromatic Hydrocarbons (PAHs)

water. Due to the presence of stable benzene rings, most of the PAHs show strong inhibition towards biological degradation and the common methods employed for their removal [37]. Naphthalene is the simplest polycyclic aromatic hydrocarbon. PAHs are ubiquitous pollutants that occur in natural phase such as soil, sediment, water, air and are harmful to environment and health of human being due to their high degree of mutagenicity and carcinogenicity [38-40]. These compounds may be classified as low molecular weights or high molecular weights (HMW) depending on the number of rings present. Low molecular weight (LMW) PAHs are relatively soluble in water but those containing 4-5 rings are hydrophobic in nature. Biodegradation of these heavier PAHs are not easy due to their poor water solubility [41,42]. The tendency to strongly adsorb on particulate matter renders the HMW PAHs less available and thus less susceptible to remediation (Cerniglia & Heitkamp, 1989). HMW PAHs have high resonance energies due to the dense clouds of π-electrons surrounding the aromatic rings making them persistent in the environment and recalcitrant to degradation (Johnson, Wick, & Harms, 2005). Low molecular weight PAHs are sometimes removed by microbial degradation and evaporation. But these conventional methods are not sufficient for the removal of stable HMW PAHs [43]. Heterogeneous photocatalysis, especially using titanium dioxide (TiO₂) have been extensively investigated to remove PAHs in aqueous solution [4,44,45]. Due to the extremely low solubility of PAHs in water, the studies mentioned above had to use organic solvent to dissolve PAHs or use surfactants to increase their solubility [15] which makes the sample analysis arduous [46,47]. Iron oxide acts as natural photocatalysts to catalyze the degradation of organic pollutants and Li et al. reported the photodegradation of pyrene
using iron oxide in solid phase [48]. Irradiation of aromatic compounds by light produces partially oxidized intermediates which are more susceptible to biodegradation than parent compounds. Thus photodegradation has been suggested as pre-treatment strategy for biodegradation [49]. This chapter discusses the photo-oxidation of some anthracene derivatives in CH₃CN using metal, non-metal modified TiO₂ under visible light.

5.2. Photo-oxidation of substituted anthracene derivatives

PAHs’ chronic health effect, carcinogenicity, microbial recalcitrance, high bioaccumulation potential and low removal efficiency in treatment process is a serious concern nowadays. So removal or degradation of these things from the environment is very necessary. Here comes the importance of advanced oxidation process (AOP). The substrates and catalysts used in the photo-oxidation reactions are shown below.

**Substrates**

![Substrates](image)

**Fig. 5.2.** 9-(N,N-Dimethylaminomethyl)anthracene and its phenyl substituted derivative
Catalysts used for photo-oxidation

a) Gd(1wt%)-N-Ti

b) Pd(1wt%)-N-Ti

c) Ag(1wt%)-N-Ti

5.2.1. Photo-oxidation of 9-(N,N-Dimethylaminomethyl)anthracene systems

Irradiated semiconductor materials are suitable candidates for some organic transformations. Here the three catalysts mentioned above have been employed for the photo-oxidation of some 9-(N,N-Dimethylaminomethyl)anthracene systems. Very simple conditions were used for the reaction. Anthracenemethanamines and phenyl substituted anthracenemethanamines can very effectively shut the communication between donor and the
acceptor species so that we can easily study the photoinduced electron transfer reactions in these systems with the presence of a catalyst. Catalysts do not have any directing nature here; it can only alter the rate of the reaction. So we obtained same products with all the three catalysts. Light response of all the three catalysts are purely in the visible region. But light absorption ability and the rate of formation of the reactive oxygen species are different for various catalysts. That may affect the yield of the products and the time taken for the reaction to be completed. The light source was either 100 W or 150 W Xe ozone free lamps with average life of 1500h. A 420-630 nm dichoric mirror (cold mirror) filter was used in order to get visible radiation which gave an irradiance of 64.7 mW/cm² (100 W) and 96.8 mW/cm² (150 W) respectively. Photo-oxidation reactions were carried out as follows. 9-(N,N-Dimethylaminomethyl)anthracene system in CH₃CN (0.03M) was taken in a 100 ml beaker and 0.1g of the Gd(1wt%)-N-Ti catalyst was added to it. The mixture was stirred for about 30 minutes to achieve an adsorption/desorption equilibrium before placing under the lamp setup. Then the suspension was irradiated using a Xenon ozone free lamp. Anthraquinone (AQ) was the only product obtained with 90% yield within 2.5h using 150 W lamps. As a control, we also carried out the same reaction without the catalyst. But no products were formed within the above said time period. In the second case, 10th position of the 9-(N,N-Dimethylaminomethyl)anthracene (0.3M) was protected by a phenyl ring and conducted the photo-oxidation and expected the same product as in the former case. Surprisingly within the time limit of 2.5h, an intermediate species 9-hydroxy 9-phenylanthrone (9H9PA) could be obtained in good yield (150 W). When the reaction time was increased to 4h, anthraquinone was obtained as the major product (89%, 150 W). The
results are tabulated in Table 5.1. The resultant mixture was centrifuged and filtered using Whatman No. 42 filter paper. This was further purified by silica column chromatography using 70:30 hexane/DCM mixtures as the mobile phase. Isolated products were thoroughly characterized using various techniques such as melting point measurement (MP), FT-IR, $^1$H NMR and GCMS analysis.

### Table 5.1. Photo-oxidation of Tertiary Amine Derivatives by using Gd(1wt%)-N-Ti System

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Time (h)</th>
<th>Products</th>
<th>Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-(N,N-Dimethylaminomethyl)anthracene</td>
<td>2.5</td>
<td>AQ</td>
<td>90</td>
</tr>
<tr>
<td>10-phenyl-9-(N,N-Dimethylaminomethyl)anthracene</td>
<td>2.5</td>
<td>9H9PA</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AQ</td>
<td>14</td>
</tr>
<tr>
<td>10-phenyl-9-(N,N-Dimethylaminomethyl)anthracene</td>
<td>4</td>
<td>AQ</td>
<td>89</td>
</tr>
</tbody>
</table>

### Table 5.2. Photo-oxidation using Pd(1wt%)-N-Ti System

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Time (h)</th>
<th>Products</th>
<th>Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-(N,N-Dimethylaminomethyl)anthracene</td>
<td>2.5</td>
<td>AQ</td>
<td>81</td>
</tr>
<tr>
<td>10-phenyl-9-(N,N-Dimethylaminomethyl)anthracene</td>
<td>2.5</td>
<td>9H9PA</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AQ</td>
<td>12</td>
</tr>
<tr>
<td>10-phenyl-9-(N,N-Dimethylaminomethyl)anthracene</td>
<td>4</td>
<td>AQ</td>
<td>80</td>
</tr>
</tbody>
</table>

### Table 5.3. Photo-oxidation using Ag (1wt%)-N-Ti System

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Time (h)</th>
<th>Products</th>
<th>Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-(N,N-Dimethylaminomethyl)anthracene</td>
<td>3</td>
<td>AQ</td>
<td>82</td>
</tr>
<tr>
<td>10-phenyl-9-(N,N-Dimethylaminomethyl)anthracene</td>
<td>3</td>
<td>9H9PA</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AQ</td>
<td>8</td>
</tr>
<tr>
<td>10-phenyl-9-(N,N-Dimethylaminomethyl)anthracene</td>
<td>4</td>
<td>AQ</td>
<td>80</td>
</tr>
</tbody>
</table>
Similar products were obtained with Pd(1wt%)-N-Ti and Ag(1wt%)-N-Ti system. But the yield and time taken for completion of the reaction were different. The light absorption ability of these catalysts are somewhat low compared to Gd(1wt%)-N-Ti, which adversely affects the formation of reactive oxygen species thereby the photo-oxidation efficiency. The results are presented in the Table 5.2 and 5.3.

The amount of the catalyst was chosen to be 0.1g since a lower amount (0.05g) gave a marginal yield and a higher amount (0.15g) made the suspension very thick for the light to transmit and resulted in a poor yield. The effect of lamp power was also studied for all the reactions using two photoreactors having powers 100 W and 150 W respectively. As expected the yield was higher with a lamp power of 150 W.

5.2.2. Photo-oxidation of 9-Anthracenemethanol

The concentration of the substrate, light source, catalyst, catalyst amount and experimental conditions are same as before. Anthraquinone (AQ) was the only product obtained after photo-oxidation of 9-Anthracenemethanol with 85% yield within 2.5h using 150 W lamp. Protection of 10th position of the compound by phenyl group leads to the formation of 9-hydroxy 9-phenylanthrone (9H9PA) in good yield. When the reaction time was increased to 4h, we obtained anthraquinone as the major product with 80% yield. But with Pd(1wt%)-N-Ti system, it takes around 3h for the completion of the reaction and the yield obtained was somewhat low. With Ag(1wt%)-N-Ti, the complete conversion of phenyl protected derivative of the substrate takes place within 3.5h. C-N bond cleavage is easy compared to C-C bond cleavage. That is, functional groups present on the anthracene systems affect the reaction time and
yield of the products. Functional groups also affect the interaction of reactive oxygen species with the substrate and the easier cleavage of the functional group reduces the time taken for the complete conversion of the substrate. The photo-oxidation results are tabulated in Table 5.4, 5.5 and 5.6.

**Table 5.4.** Photo-oxidation of Anthracenemethanol using Gd(1wt%)-N-Ti

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Time (h)</th>
<th>Products</th>
<th>Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-Anthracenemethanol</td>
<td>2.5</td>
<td>AQ</td>
<td>85</td>
</tr>
<tr>
<td>10-phenyl-9-anthracenemethanol</td>
<td>2.5</td>
<td>9H9PA</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AQ</td>
<td>11</td>
</tr>
<tr>
<td>10-phenyl-9-anthracenemethanol</td>
<td>4</td>
<td>AQ</td>
<td>80</td>
</tr>
</tbody>
</table>

**Table 5.5.** Photo-oxidation of Anthracenemethanol using Pd(1wt%)-N-Ti

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Time (h)</th>
<th>Products</th>
<th>Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-Anthracenemethanol</td>
<td>3</td>
<td>AQ</td>
<td>81</td>
</tr>
<tr>
<td>10-phenyl-9-anthracenemethanol</td>
<td>3</td>
<td>9H9PA</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AQ</td>
<td>9</td>
</tr>
<tr>
<td>10-phenyl-9-anthracenemethanol</td>
<td>4</td>
<td>AQ</td>
<td>77</td>
</tr>
</tbody>
</table>

**Table 5.6.** Photo-oxidation of Anthracenemethanol using Ag(1wt%)-N-Ti

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Time (h)</th>
<th>Products</th>
<th>Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-Anthracenemethanol</td>
<td>3</td>
<td>AQ</td>
<td>80</td>
</tr>
<tr>
<td>10-phenyl-9-anthracenemethanol</td>
<td>3.5</td>
<td>9H9PA</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AQ</td>
<td>8</td>
</tr>
<tr>
<td>10-phenyl-9-anthracenemethanol</td>
<td>4</td>
<td>AQ</td>
<td>76</td>
</tr>
</tbody>
</table>
5.2.3. Photo-oxidation of 9-Anthraldehyde

Nanoparticles such as metal, metal oxide and metal sulfides can catalyze many chemical transformations in organic synthesis including reduction, oxidation, cross coupling or hydrogenation [50-52]. The experimental set up and reaction conditions are same as before. Anthraquinone (82%) was obtained from anthraldehyde with a time period of 3.5h using Gd(1wt%)-N-Ti. Photo-oxidation of phenyl protected anthraldehyde favored 9-hydroxy 9-phenylanthrone (9H9PA) with 70% yield. The formed intermediate species eventually transformed to anthraquinone as the time increased to 4h. Same products were obtained with the other two catalysts. Here the aldehyde group is directly attached to the anthracene moiety. Cleavage of C-O bond is rather difficult than C-C and C-N cleavages. The rate of formation of reactive oxygen species and its feasibility to interact with the substrate affects the yield and time of the reaction. The results are tabulated in Table 5.7, 5.8 and 5.9.

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Time (h)</th>
<th>Products</th>
<th>Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-Anthraldehyde</td>
<td>3.5</td>
<td>AQ</td>
<td>82</td>
</tr>
<tr>
<td>10-phenyl-9-anthraldehyde</td>
<td>3.5</td>
<td>9H9PA</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AQ</td>
<td>9</td>
</tr>
<tr>
<td>10-phenyl-9-anthraldehyde</td>
<td>4.5</td>
<td>AQ</td>
<td>78</td>
</tr>
</tbody>
</table>

Table 5.7. Photo-oxidation of Anthraldehyde by Gd(1wt%)-N-Ti
Table 5.8. Photo-oxidation of Anthraldehyde using Pd(1wt%)-N-Ti

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Time (h)</th>
<th>Products</th>
<th>Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-Anthraldehyde</td>
<td>3.5</td>
<td>AQ</td>
<td>79</td>
</tr>
<tr>
<td>10-phenyl-9-anthraldehyde</td>
<td>4</td>
<td>9H9PA</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AQ</td>
<td>12</td>
</tr>
<tr>
<td>10-phenyl-9-anthraldehyde</td>
<td>4.5</td>
<td>AQ</td>
<td>78</td>
</tr>
</tbody>
</table>

Table 5.9. Photo-oxidation of Anthraldehyde by Ag(1wt%)-N-Ti

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Time (h)</th>
<th>Products</th>
<th>Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-Anthraldehyde</td>
<td>4</td>
<td>AQ</td>
<td>70</td>
</tr>
<tr>
<td>10-phenyl-9-anthraldehyde</td>
<td>4</td>
<td>9H9PA</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AQ</td>
<td>11</td>
</tr>
<tr>
<td>10-phenyl-9-anthraldehyde</td>
<td>5</td>
<td>AQ</td>
<td>69</td>
</tr>
</tbody>
</table>

Fig. 5.5. General Reaction Mechanism for Anthracene Derivatives
Light and molecular oxygen are the two major driving forces in photo-oxidation reactions. The reaction does not occur without catalyst, oxygen or in the dark. In this reaction, molecular oxygen was not added to the reaction mixture externally. However, the reaction efficiencies in oxygen atmosphere and air atmosphere are comparable. Upon irradiation with visible light, electrons in the valance band of the catalyst could get excited and get accumulated in the conduction band. These electrons could easily be captured by molecular oxygen adsorbed on the catalyst surface to form some reactive oxygen species which in turn react with the substrate molecules. Molecular oxygen not only acts as a scavenger for electrons but is also responsible for producing some reactive species. The superoxide anion (reactive oxygen species) formed reacts with the substrate to form endoperoxide. This was eventually decomposed to anthraquinone through β-Scission. The phenyl ring at the 10th position reduces the feasibility of photo-oxidation reaction and the stability of the
intermediate compound allows its easy identification and separation. Increasing the reaction time leads to extensive degradation resulting in the loss of phenyl group to form anthraquinone (AQ). The intermediate species 9-hydroxy 9-phenylanthrone (9H9PA) was formed from endoperoxide through $\beta$-Scission and hydrogen abstraction. It then rearranges to form the final product via $\beta$-Scission.

![Plausible way of interaction of reactive oxygen species with the substrate in Ag,N co-doped TiO$_2$ system](image)

**Fig.5.7.** Plausible way of interaction of reactive oxygen species with the substrate in Ag,N co-doped TiO$_2$ system

Usually, metals can exist as a metal island on the surface of the catalyst. It can act as the scavenger for electrons excited from the valance band upon irradiation only when the work function of these metals are high compared to the semiconductor materials. So these electrons can easily be captured by molecular oxygen adsorbed on the surface through metal to form reactive oxygen species. It then interacts with the substrate molecule adsorbed on the surface favoring the products.
5.3. Characterization of Anthraquinone (AQ)

Melting point of the compound was found to be 284°C which is well in accordance with the reported results. FT-IR spectrum of the compound shows a strong band around 1670 cm⁻¹ corresponding to C=O stretching vibration. The band at 896 cm⁻¹ represents the stretching of substituted benzene ring. ¹H NMR spectrum of the compound shows two doublet of doublets at ‘δ’ value in the range of 7.8-8.34 ppm indicating two sets of four equivalent protons. GCMS spectrum shows m/z value at 208 corresponds to the M⁺ peak of anthraquinone and it shows an M-28 peak at 180. All these characterizations confirm the formation of compound Anthraquinone (AQ).

5.4. Characterization of 9-hydroxy 9-phenylanthrone (9H9PA)

The melting point (MP) of the compound is 216°C which agrees with the already reported results. FT-IR spectrum shows two strong bands at 3416 cm⁻¹ and 1600 cm⁻¹ corresponding to the O-H stretching and bending vibrations respectively. Another prominent peak at 2922 cm⁻¹ corresponds to C-H stretching vibration. Proton NMR spectrum of the compound shows multiplets having ‘δ’ value around 7.07-7.75 ppm representing the 13 aromatic protons. Compound 4 (9-hydroxy 9-phenyl anthrone) shows M⁺ peak at m/z 286 and M-77 peak at 209.

5.5. Conclusion

Semiconductor catalysis is an effective and greener way for the removal of environmentally harmful substances. Cost effective, recyclable and environmentally benign co-doped TiO₂ catalysts were successfully employed for the photo-oxidation of some anthracene derivatives in the
visible region. Here all the three catalysts showed comparable activity. Yield of the product and the time taken for the completion of the reaction are different for all the catalysts. The catalysts were found to be very active for the photo conversion of anthracene derivatives to Anthraquinone, a compound having diverse applications in industrial as well as medical fields. Substitution of the 10th position by a phenyl ring favored 9-hydroxy 9-phenylanthrone (9H9PA) as an intermediate species. The toxicity of this compound was also found to be lower compared to the starting compounds.

References


