THE 13TH INTERNATIONAL CONFERENCE ON QiR
(QUALITY in RESEARCH)

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25-28 June 2013

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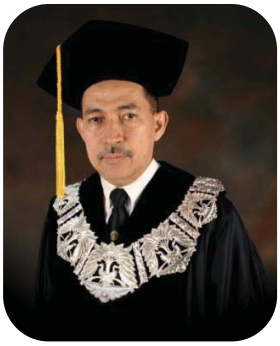
WELCOME FROM THE RECTOR OF UNIVERSITAS INDONESIA



It is both a pleasure and honor for me to welcome you all to the 13th International Conference on QiR (Quality in Research) 2013. In this globalization era, mankind's competitive explorations to find new and better ways to enhance their life has often resulted in sacrificing the environment for their convenience. To preserve the environment for our future generations, steps must be made to ascertain that development and innovation of mankind must be more sustainable, balancing both mankind's' effort in enhancing their quality of life and fulfilling their needs, with its harmony with nature.

Today, scientists and experts, in particular, people in engineering, architecture and design are looking to develop new environmentally friendly technologies, or eco-technologies. Innovation in eco-based multidisciplinary knowledge and skills becomes the important key, and this central issue should be encouraged for the motivation of current and future development. Eco-technology can help protect, conserve and even restore our precious shared environment. To develop this technology, we need to combine engineering, scientific or technological approaches, with ecology, economics and the social sciences and humanities. The eco-innovation field is now wide open and offers exciting new territories to explore and develop. Creative thinking by our top technical and scientific researchers is giving us a more and more treasures of new workable ideas.

However, innovations require more than just brilliant ideas. Innovations require resources, skills, technology, knowledge, tools, techniques and so much more. But most of all, innovations require people. People are the driving force behind every need of change, changes that are aimed to improve mankind's quality of life, to enhance their living conditions or to simply make life easier and more comfortable. This conference is about learning of the fundamental aspects which can transform the world and society, thinking ahead to possible challenges facing the globe, discovering innovations related to opportunities for industry, and most importantly, this conference is about bringing together interdisciplinary people to accelerate activities in many areas simultaneously. This is what makes the conference exceptional this year in terms of potential impact from this networking.

I extend my sincere thanks to the Faculty of Engineering Universitas Indonesia, supporting parties and institutions for their participation and contributions in QiR 2013. I would also thank the people of Yogyakarta for their gracious support and hospitality. Additionally, I extend a hearty thank you to the members of the organizing committees for dedicating their valuable time so that each one of us enjoys an exceptional conference program over the next several days. May we have a successful, stimulating, fruitful and rewarding conference.

Prof. Dr. Ir. Muhammad Anis M.Met.
Rector
Universitas Indonesia

WELCOME FROM THE DEAN OF FACULTY OF ENGINEERING UNIVERSITAS INDONESIA

Welcome to the 13th International Conference on QiR (Quality in Research) 2013. The Faculty of Engineering Universitas Indonesia is thrilled that, together with our co-hosts IST-Akprind and Gadjah Mada University, we are able to present an international conference of this magnitude. This two-day conference speaks to the importance of fostering relationships among national and international front liners, thinkers, academics, executives, government and business officials, practitioners and leaders across the globe in an effort to share knowledge and best practices as part of a worldwide network.

The quest for knowledge has been from the beginning of time but knowledge only becomes valuable when it is disseminated and applied to benefit humankind. It is hoped that QiR 2013 will be a platform to gather and disseminate the latest knowledge in engineering, architectural design and community services. Academicians, scientist, researchers and practitioners of these fields will be able to share and discuss new findings and applications of their expertise. It is envisaged that the intellectual discourse will result in future collaborations between universities, research institutions and industry both locally and internationally. In particular it is expected that focus will be given to issues on innovations for the enhancement of human life and the environment.

In accordance to this year's theme, this conference will cover a wide range of sustainable design and technology issues, especially state of the art information and knowledge of new innovations, ideas, creative methods or applications which can be implemented to enhance the human life and also our environment. The itinerary of the conference over the two days has been carefully planned to ensure a lively exchange of ideas and the development of innovative strategies and there will be many opportunities for everyone in attendance to share their expertise with, and learn from, peers from around the world.

We urge you to spend the next two days in interesting discussions and exchanging ideas among yourselves. We foresee more and more challenges in our future. Challenges in how to improve our life, how can we enhance our society, how can we make our lives and the lives or our society better? These challenges should be answered together by developing collaborations for future research in various engineering and design areas. It is our hope and aim that this conference would be able to provide an international media for exchange of the knowledge, experience and research as well as the review of progress and discussion on the state of the art and future trend of prospective collaboration and networking in broad field of eco-based technology development.

My deepest appreciation to our sponsors, supported parties and various contributors for their never ending supports of this conference. I would also like to convey my humblest thankfulness to all of our distinguished speakers for making the time to share their knowledge with us. To our fellow researchers and/or practitioners from Indonesia and overseas, welcome and enjoy your stay in this amazing historical city, Yogyakarta. I would also like to invite all participants in expressing our appreciation to all members of the QiR 2013 organizing committee for their hard work in making this conference another success.

Prof. Dr. Ir. Bambang Sugiarto, M.Eng.
Dean Faculty of Engineering
Universitas Indonesia

WELCOME FROM THE QiR 2013 ORGANIZING COMMITTEE

Welcome to the 13th International Conference on QiR (Quality in Research) 2013. It is a great pleasure for Faculty of Engineering Universitas Indonesia to be co-hosting this biennial event with IST-Akprind and Gadjah Mada University, in the spirit of strengthening of cooperation and mutual growth to be world class institution. For the first time, the QiR 2013 is held in one of the most historical city in Indonesia – Yogyakarta. It is with our utmost pleasure to hold this year's QiR 2013 in conjunction with the 2nd International Conference on Civic Space (ICCS 2013) and introducing the International Symposium on Community Development 2013 as a forum to share experience on engaging community for a better life and environment.

The aim of this International Conference with our selected theme, "Exploring Innovation for Enhancement of Human Life and Environment", is to provide an international forum for exchanging knowledge and research expertise as well as creating a prospective collaboration and networking on various fields of science, engineering and design. We hope this conference can be a kick-off for the strengthened action and partnerships on creating a platform for us; national and international thinkers, academics, government officials, business executives and practitioners, to present and discuss the pivotal role of engineers in innovative products which will reduce environmental impacts, applications in sustainable planning, manufacturing, architecture, and many more to grow and ensure the rising prosperity of our society going into the future. Under this theme, the conference focuses on the innovative contributions in science, engineering and design as well as their market perspectives to the existing and future enhancement of human life and environment quality.

Over the period of 15 years, this biennial conference has become an important place of encounter between scholars and practitioners from different countries, cultures and backgrounds discussing contemporary engineering and design issues dealt in their hometown, country or even region. Serving as a platform for an engineering and design dialogue, this conference will have 16 invited speakers and has gathered more than 500 papers from more than 20 countries all over the world:
92 papers on International Symposium on Civil and Environmental Engineering
51 papers on International Symposium on Mechanical and Maritime Engineering
97 papers on International Symposium on Electrical and Computer Engineering
111 papers on International Symposium on Materials and Metallurgy Engineering
31 papers on International Symposium on Architecture, Interior and Urban Planning
57 papers on International Symposium on Chemical and Bioprocess Engineering
71 papers on International Symposium on Industrial Engineering
25 papers on International Symposium on Community Development

My deepest gratitude to all of our speakers, participants and contributors who have given this conference their generous support. I would also like to thank all members of the Organizing Committee and our distinguished International Board of Reviewers for all of their support and advice. Our thanks to all of our sponsors, supporters, exhibitors, and professional associations for their great support and encouragement through committed funding and any other form of help and support. We also owe our success to the full support of the Rector of Universitas Indonesia and the Dean of Faculty of Engineering. Thank you to IEEE Indonesia Section that has supported QiR 2013 to be approved as IEEE Conference. Last but not least, a special thanks to our co-hosts, IST-Akprind and Gadjah Mada University for all of their immense supports in making this conference a success.

Allow me to wish all of you a meaningful and rewarding conference. We wish you a pleasant and memorable stay in Yogyakarta. Thank you and we hope to see you again at the QiR 2015.

Prof. Dr. Ir. Bondan T. Sofyan, M.Si.
Chairman of QiR 2013 Organizing Committee

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Solar-induced photocatalytic decolorization of reactive dye by using immobilized nano particles of titanium dioxide

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ABSTRACT

Most of textile industries today used the synthetic dyes which recalcitrant in nature and contain of the dangerous-poisonous material property. However, the application of the synthetic color can be harmful to the environment because the colored wastewater produced from their processes is difficult to degrade.
The application of Advanced Oxidation Processes (AOPs) for dye wastewater treatment is the focus of this study. Photocatalysis as one of AOPs was applied for the decolorization of organic content of synthetic dye wastewater. The reactive dye, C.I. Reactive Red 2 (RR2) was used as the model organic pollutants.
In this research, the bulk and nano particle of titanium dioxide (TiO_2) catalyst were immobilized on a plastic surface. The solar-induced photocatalytic decolorization process was performed in a 220 mL of cylinder glass reactor. The catalyst concentration was varied from 0 to 0.4 g/mL. The RR2 concentration was varied between 25-100 mg/L. Degradation of organic content in the pollutant was examined in the term of color removal within 0-15 hrs under solar irradiation. By using a dye concentration of 25 mg/L and the catalyst concentration of 0.4 g/mL, a color degradation of 95% and 46% was achieved when using nano and bulk TiO_2 respectively, after irradiation for 15hours. A pH of 6-7 was observed during the process.

Keywords
Advanced Oxidation Processes (AOPs), Photocatalysis, Immobilized Titanium dioxide, Reactive Dye, Solar induced

1. INTRODUCTION

Textiles industries generate great volume of colored dye effluents which are toxic and recalcitrant in nature. These dyes create severe environmental pollution problems by releasing toxic and potential carcinogenic substances into the aqueous phase. Various chemical and physical processes such as precipitation, adsorption, air stripping, flocculation, reverse osmosis and ultrafiltration can be used for color removal from textile effluents [1-5].

However, among various physical, chemical and biological techniques for treatment of wastewaters, heterogeneous photocatalysis has been considered as a cost-effective alternative for water remediation. Photocatalytic degradation has been shown to be one of the most promising processes for the wastewater treatment due to its advantages over the traditional techniques, such as quick oxidation, no formation of polycyclic products, and oxidation of pollutants in the very small [6-9].

In recent years Advanced Oxidation Processes (AOPs) using Titanium dioxide (TiO_2) has been effectively used to detoxify recalcitrant pollutants present in industrial wastewater [10-13]. The TiO_2catalyst have singular characteristics that made it an very attractive photocatalyst i.e. high photochemical reactivity, high photocatalytic activity, low cost, stability in aquatic systems and low environmental toxicity [14].

Although Titanium dioxide suspensions yield higher reaction rates, the use of immobilized particles of TiO_2 is desirable for two reasons, firstly, the need for separation of TiO_2 from the reacted solutions can be avoided and secondly, they would allow application to solar photocatalysis. Solar induced photocatalysis has been an intensive area of research [15-17], where the use of large area TiO_2-coated surfaces is very important. Many researchers have developed various methods to apply TiO_2 coating on various substrates [18]. TiO_2 was immobilized on ceramic [19], fiber glass [20], sand [21], rigid support (glass, quartz, and stainless steel) [22], pebbles [23], activated carbon [24], polystyrene beads

[25], zeolites [26], and acrylic plastic [27]. The TiO_2 immobilized substrates have been successfully used for the photocatalytic degradation of several organic pollutants. However, to the best of our knowledge, the use of thermoplastic polymer resin such as Polyethylene terephthalate (PET) plastic has not been reported. In the present study the TiO_2 was immobilized on the PET plastic. The immobilized particles were prepared by using the bulk and the nano particle of TiO_2. The solar induced photocatalytic decolorization of reactive dye by using immobilized TiO_2 was investigated in this research.

Over 700,000 types of approximately 10,000 types of dyes and pigments are produced annually worldwide. From this amount, about 20% are discharged as industrial effluents during the textile dyeing and finishing processes without previous treatment [28]. Reactive dyes have been identified as the most environmental problematic compounds in textile dye effluents [29]. Moreover, research on textile effluent decolorization has focused on fiber reactive dyes [30] for the following reasons. Firstly, reactive dyes represent an integral market share (almost 45% of all textile dyes produced annually belong to the fiber reactive class). Secondly, these dyes have low fixation rates, which results in highly colored spent dye-baths whose treatment is inadequate in conventional wastewater treatment plants [31]. Thirdly, of special concern is the reactive dyeing process, where on average of 10 times more water is consumed for preparation, dyeing, washing and rinsing stages than for dyeing with other dye types.

Reactive textile dye, namely C.I. Reactive Red 2 (RR2) was chosen as recalcitrant model pollutant. The chemical structure and some properties of the reactive dyes are presented in Figure 1 and Table 1. This type of dye was selected for this study since its molecular structure is known and the dye is frequently being applied for the dyeing of cotton and nylon (polyamide) at the traditional cloth industries in development countries such as Indonesia and India.

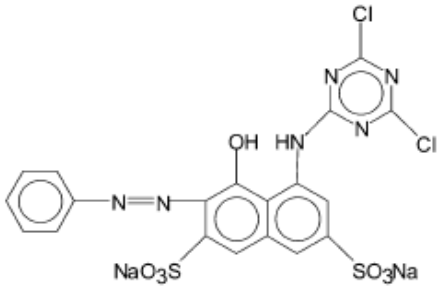

Figure 1. Chemical structure of C.I. Reactive Red 2

Table 1. *Properties of C.I. Reactive Red 2*

Dye	C.I. Reactive Red 2
Chemical formula	$C_{19}H_{10}Cl_2N_6Na_2O_7S_2$
Molecular weight (g/mol)	615
C.I. number	18200
λ max (nm)	538

The use of solar energy to initiate the photodegradation of some organic pollutants, such as textile effluents, has been widely reported [32]. The solar energy is not widely used in tropical countries like Indonesia, although it is a free, renewable and environmentally friendly energy source. The objective of the research is to study the solar induced photocatalytic decolorization of RR2 dye using TiO_2-coated PET plastic in the term of color degradation. In this paper, the effects of the amount of TiO_2 used (catalyst concentration), initial concentration of the dye, and pH were also examined.

2. MATERIALS DAN METHODS

The synthetic dye wastewater was prepared by using C.I Reactive Red 2 (RR 2) obtained from Fajar Setia Dyestuff in Jakarta and was used without further purification. The RR2 concentration was varied

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between 25-100 mg/L. The TiO_2 anatase powder and TiO_2 anatase nano-powder were received from Sigma–Aldrich. The solvent (acetone) and adhesive (cyanoacrylate) was found from the chemical store.

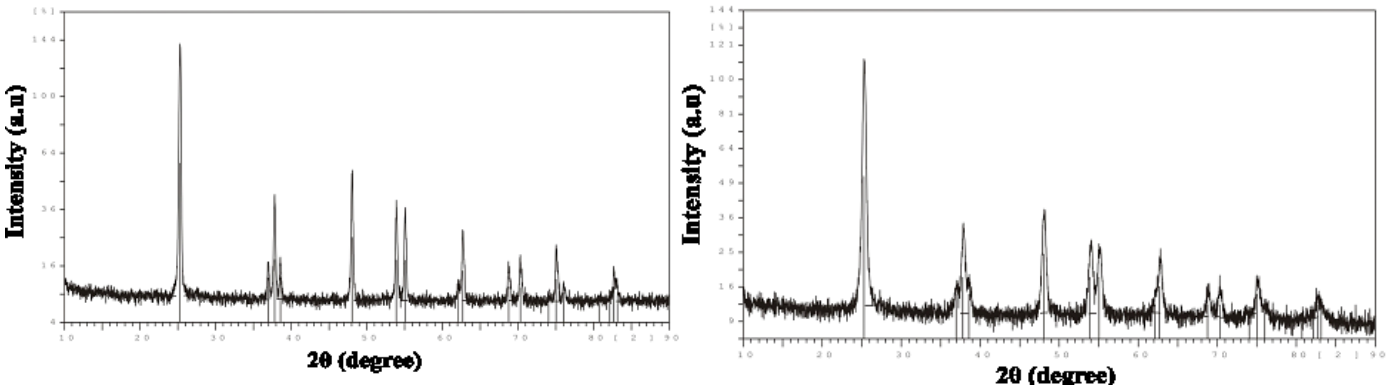
The coating process was accomplished by mixing the TiO_2 catalyst with acetone in the 250 ml beaker glass. The catalyst concentration was varied from 0.05 to 0.4 g/mL. The certain amount of catalyst was dissolved in 10 mL of acetone until a homogeneous solution recognized. Add the cyanoacrylate adhesive to the solution and stir slowly, followed by putting the plastic then stir until the thick solution obtained. Take the coated plastic and place in the room air. Allow the plastic dry in the room temperature.

The solar-induced photocatalytic decolorization was carried out in batch operation in a cylinder glass type of reactor. The reactor capacity is 220 ml with 7 cm of inside diameter and 5.7 cm of height. RR2 dye solution was prepared in distilled water, within the concentration of 25-100 mg/L. For every experiment performed, the reactor was initially loaded with 200 ml of RR2 aqueous solution, and then put TiO_2-coated plastic. The color degradation was observed every 3 hrs between 9 am and 3 pm under the sunlight for 2 days. The reactor was retained in the dark place when the experiment pending.

The TiO_2 nano particles catalysts were characterized by X-ray diffraction (XRD) and scanning electron microscope (SEM). The crystalline phases were determined by using a X-ray diffraction measurements (PC-APD Philip) with Cu tube anode, operated at 40 kV and 30 mA. A Scanning Electron Microscope (SEM), JEOL SEM-330 JAPAN was used to examine the surface morphology of TiO_2-coated plastic. Color degradation was measured by HACH Spectrophotometer. Degradation percentage of dye is defined as follows:

$$\text{Color degradation percentage} = ((C_o - C_t)/C_o) \times 100\% \quad (1)$$

Where C_o (mg/l) is the initial concentration of dye, and C_t (mg/l) is the concentration of dye at reaction time t (hr).

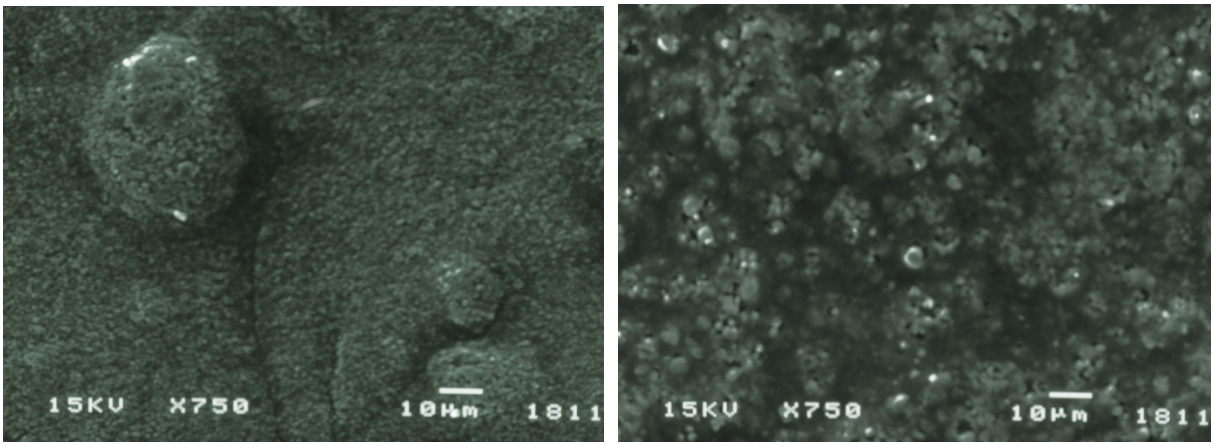


(a) **(b)**

Figure 2. XRD patterns of (a) anatase powder of TiO_2 as prepared (b) anatase nano-powder of TiO_2 as prepared

Figure 2 displays the X-ray diffraction (XRD) pattern of anatase powder and anatase nano-powder of TiO_2 as prepared. All characteristic lines are attributed to the anatase phase confirmed by the XRD analysis results. The average crystallite size of anatase nano-powder of TiO_2 sample calculated from XRD line broadening using Scherrer equation is 37 nm.

Photocatalytic decolorization process was studied by using the coated anatase powder and nano-powder TiO_2 catalyst on the PET plastic. The surface morphology of TiO_2-coated plastic by means of 0.4 g/mL catalyst concentration can be shown in Figure 3. More aggregate of TiO_2 were observed when the nano-powder TiO_2 catalyst applied as demonstrated in the SEM images.

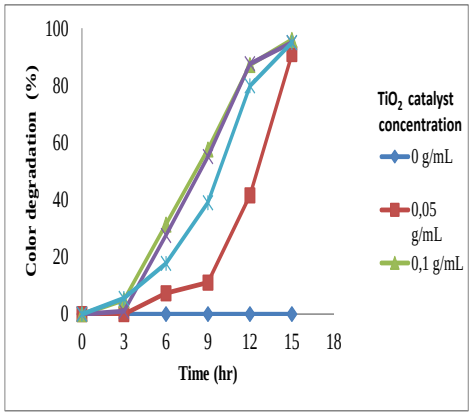


(a) **(b)**

Figure 3. SEM images of 0.4 gr/ml TiO_2 (a) anatase powder-coated plastic (b) anatase nanopowder-coated plastic

3. RESULTS AND DISCUSSION

With increasing the exposure time, as shown in Figures 4-6, it can be seen that the percent of color degradation will increase. Those situations occur consistently when using the RR2 concentration of 25, 50, and 100 mg/L. This is due to the increase in exposure time the greater the chances of photocatalytic reaction to take place. With increasing the energy received more hydroxyl radicals are formed to oxidize the dye compound which interrupted its double bonds and break down into a simpler compounds.



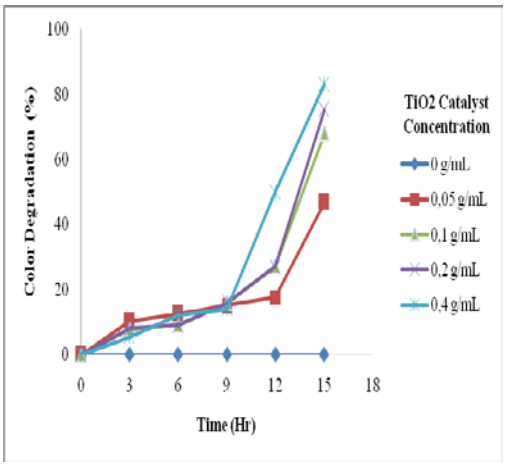


Figure 4. Color degradation at various catalyst catalyst concentration of 25 mg/L of RR2

Figure 5. Color degradation at various concentration of 50 mg/L of RR2

By using the different dye concentrations, it can be shown from the figure that increasing the dye concentration will decrease the percent of color degradation. The use of 0.4 gr/mL catalyst concentration result in the color degradation of 95%, 83%, and 71% when treat the RR2 concentration of 25 mg/L 50 mg/L, and 100 mg/L, respectively. It can be explained that the higher dye concentration means more molecule of dye present in the solution, so by consuming the same amount of energy, the less concentrate dye will give the higher of color degradation.

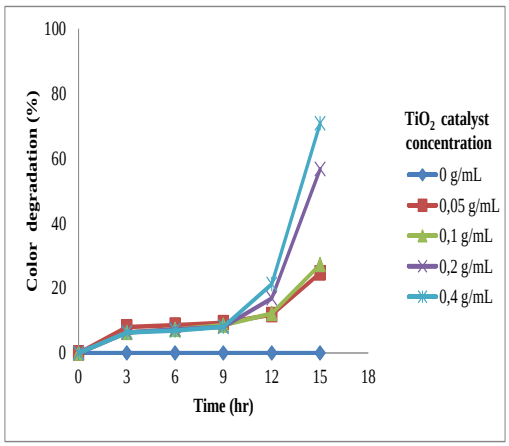


Figure 6. Color degradation at various catalyst concentration of 100 mg/L of RR2

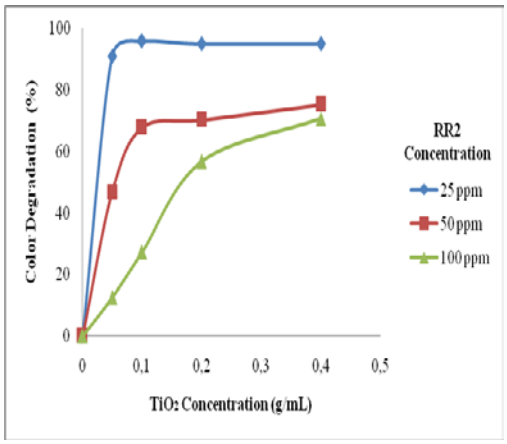


Figure 7. Effect of RR2 concentration on color degradation percentage at various catalyst concentration for 15 hours of exposure time

The effect of dye concentration on the color degradation at various catalyst concentration coated on the plastic can be drawn in Figure 7. As the concentration of dye increase, the color degradation percentage will decrease. For 15 hours of exposure time, the highest color degradation of 95% was obtained when using the smallest RR2 concentration, namely 25 mg/L. The effect of catalyst concentration was also examined in this study. For 15 hours of exposure time, the highest color degradation was reached by applying the catalyst concentration of 0.4 g/mL at RR2 concentration of 25 mg/L, as illustrated in Figure 8.

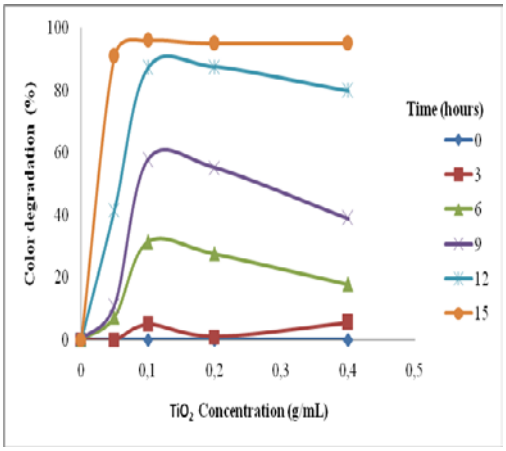


Figure 8. Effect of TiO_2 catalyst concentration powder on color degradation percentage of RR2 concentration of 25 mg/L

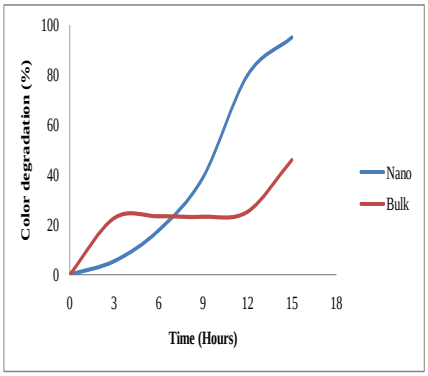


Figure 9. Color degradation of 0.4 g/mL anatase and anatase nano-powder TiO_2 at RR2 concentration of 25 mg/L

By using a RR2 concentration of 25 mg/L and the catalyst concentration of 0.4g/mL, a color degradation of 95% and 46% was achieved when using nano and bulk-TiO_2 respectively, after irradiation for 15 hours, as can be presented in Figure 9. Because the nano-scale of TiO_2 possess higher surface area-to-volume ratio than their equivalent bulk, and thus allow for greater photon absorption on the catalyst surface. Moreover, recombination of the electron hole pair within the semiconductor particle is drastically reduced as particle size decreases. With decreasing particles size of semiconductor to nanometer-scale, the band gap energy greatly increased, which in turn led to higher redox potentials in the system. Therefore, the nano-scale semiconductor such as nano TiO_2 is expected to have higher photocatalytic activity than its bulk [33, 34].

The pH may affect the surface charge on the catalyst. In photocatalytic process, pH is important and influence to the reaction rate. Also, industrial effluents may be basic or acidic and therefore pH effect must be studied. In this experiments the pH before and after treatment were observed. A pH of 6-7 was detected during the photocatalytic decolorization process for 15 hours. The pH range was considered within the optimum range for the photocatalytic reaction take place as reported in other study [35].

4. CONCLUSION

The application of Advanced Oxidation Processes (AOPs) for synthetic dye wastewater treatment is the focus of this study. The solar-induced photocatalysis process as one of AOPs was applied for the decolorization of C.I. Reactive Red 2 (RR2). In this research, the bulk and nano-particle of titanium dioxide (TiO_2) as photocatalyst were immobilized on a plastic surface. Degradation of organic content was examined in the term of color removal. By using a dye concentration of 25 mg/L and the catalyst concentration of 0.4 g/mL, a color degradation of 95% and 46% was achieved when using nano and bulk-TiO_2 respectively, after irradiation for 15 hours. A pH of 6-7 was observed during the process.

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