Academic Year 2016-17

6. Preparation, characterization and Application of Nano crystalline Multilayer Transparent Oxide Thin Films

Index

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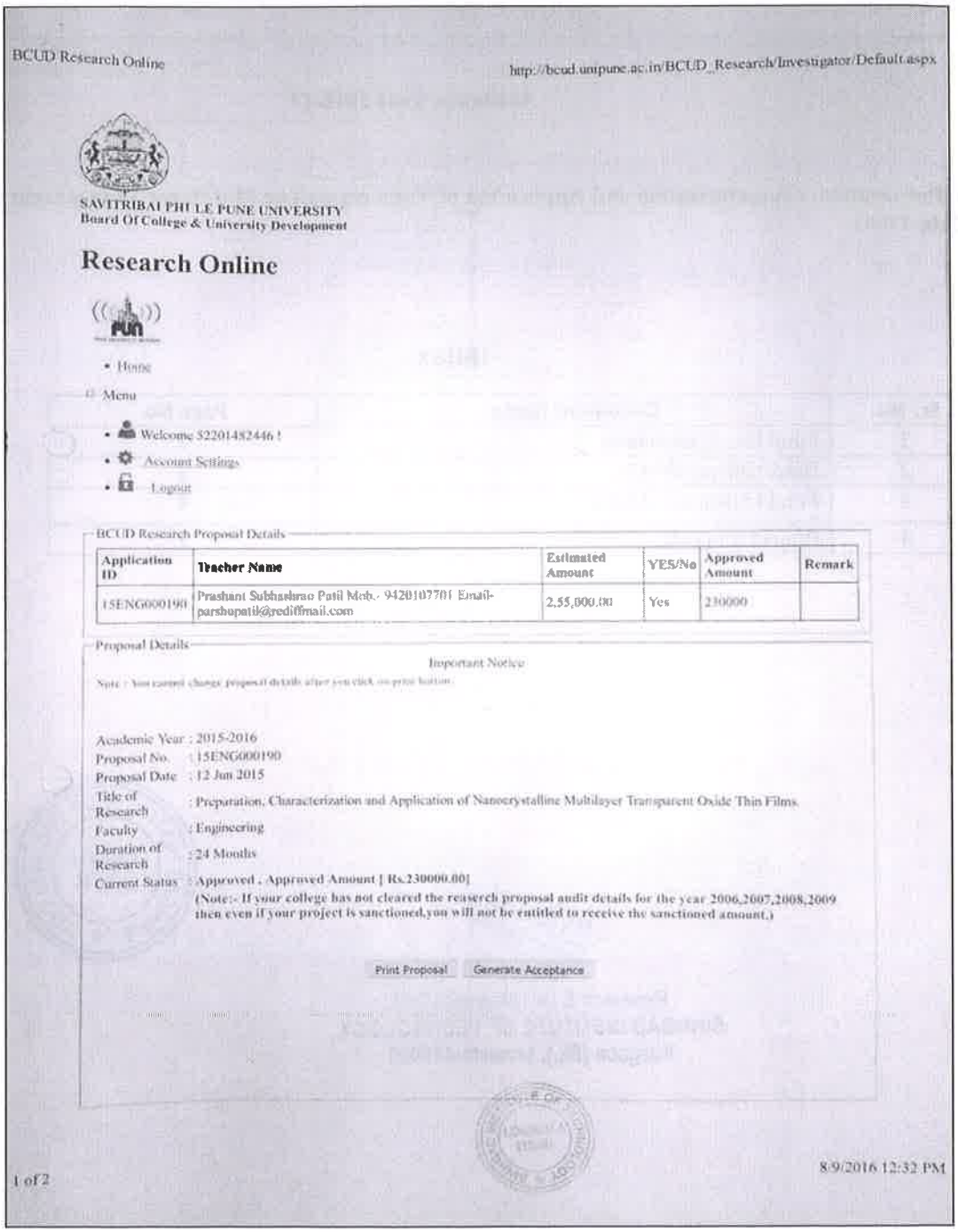
Fund Received details



BCUD Research Online http://bcud.unipune.ac.in/BCUD_Research/Investigator/Default.aspx

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Research Online

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BCUD Research Proposal Details

Application ID	Teacher Name	Estimated Amount	YES/No	Approved Amount	Remark
15ENG0000190	Prashant Subhashrao Patil Mob.- 9420107701 Email-parshupatil@rediffmail.com	2,55,000.00	Yes	230000	

Proposal Details

Important Notice

Note : You cannot change proposal details after you click on print button.

Academic Year : 2015-2016
Proposal No. : 15ENG0000190
Proposal Date : 12 Jun 2015
Title of Research : Preparation, Characterization and Application of Nanocrystalline Multilayer Transparent Oxide Thin Films.
Faculty : Engineering
Duration of Research : 24 Months
Current Status : Approved . Approved Amount [Rs.230000.00]
(Note:- If your college has not cleared the research proposal audit details for the year 2006,2007,2008,2009 then even if your project is sanctioned,you will not be entitled to receive the sanctioned amount.)

Print Proposal | Generate Acceptance

1 of 2 8/9/2016 12:32 PM

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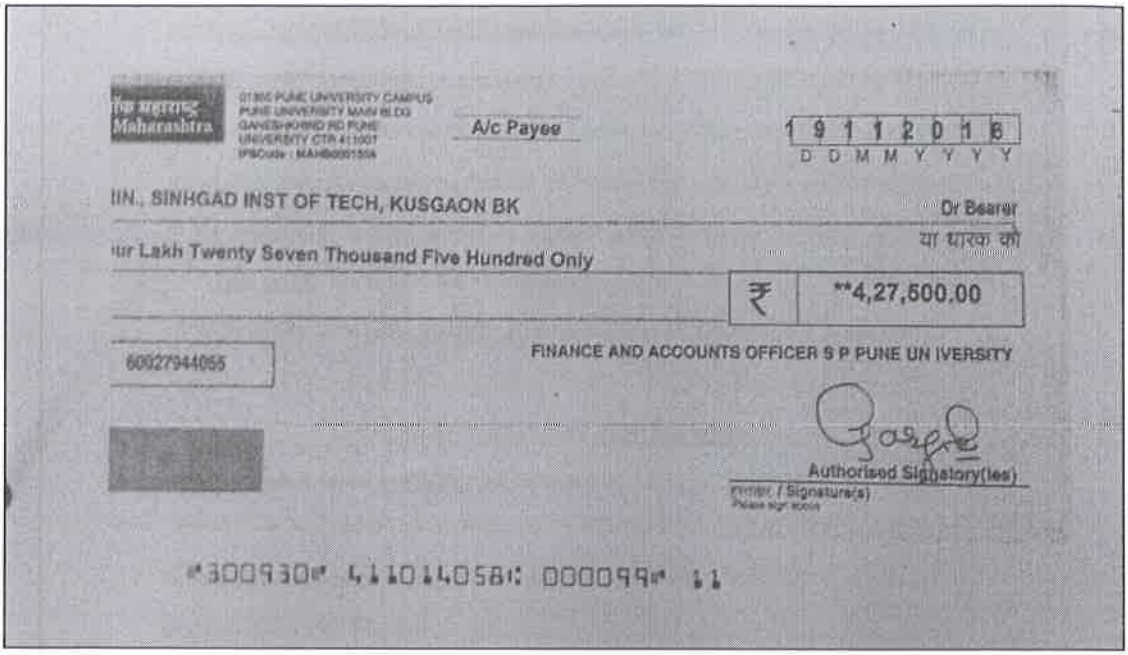
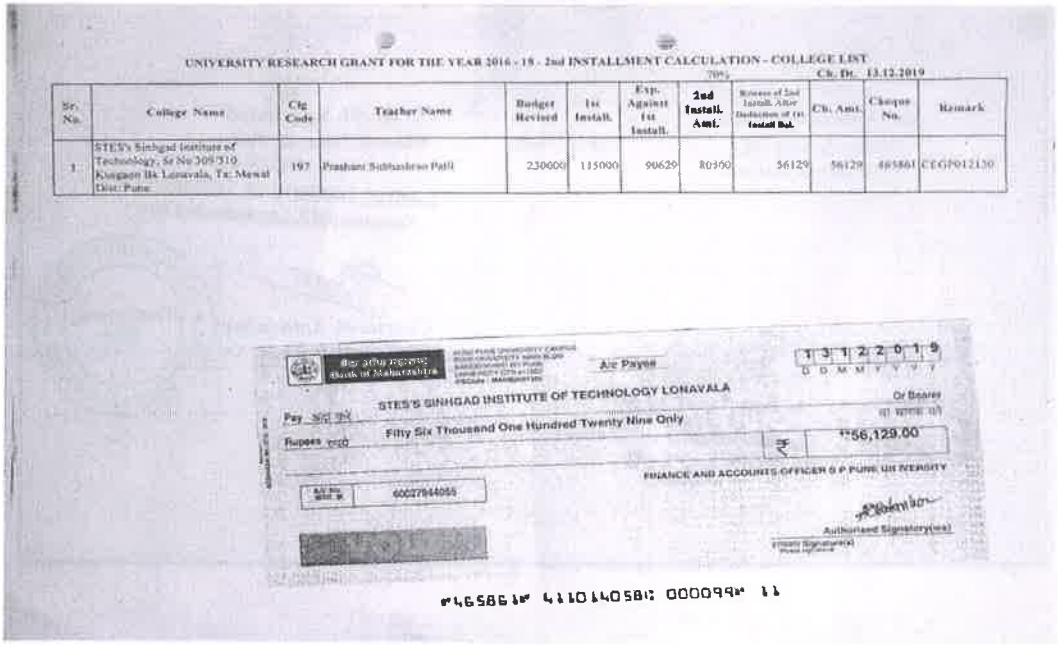
Bank Cheque details



Second Installment



UNIVERSITY RESEARCH GRANT FOR THE YEAR 2016 - 18 - 2nd INSTALLMENT CALCULATION - COLLEGE LIST

Cs. Dt. 13.12.2019

Sr. No.	College Name	Clg Code	Teacher Name	Budget Revised	1st Install.	Exp. Against 1st Install.	70% 2nd Install. Amt.	Balance of 2nd Install. After Deduction of 1st Install Bal.	Cs. Amt.	Cheque No.	Remark
1	STES's Sinhgad Institute of Technology, Sr No 309/310 Kusgaon Bk Lonavala, Tal Mawal Dist: Pune	197	Prashant Subhashrao Patil	230000	115000	90629	80500	56129	56129	485861	CEGP012130

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Fund Utilization details

UTILISATION CERTIFICATE

Certified that the accounts of the STES's Sinhgad Institute of Technology, Lonavala College in respect of "Preparation, Characterization and Application of Nanocrystalline Multilayer Transparent Oxide Thin Films". Research Project of Dr. Prashant S. Patil, Principal Investigator (P.I.) have been audited by me with reference to the Vouchers, books of accounts, norms of expenditure and relevant guidelines there to. The Statement of expenditure of Research Project duly signed by me is enclosed, for the year 2016 – 2017.

1. It is hereby certified that the total grants of Rs. 2,30,000 /- has been sanctioned to the Principal Investigator (P.I.)
2. The P.I. has received Rs. 1,15,000 /- towards the 1st Installment.
3. The P.I. has incurred the total expenditure of Rs. 1,06,056 /- for the Research Project against 1st Installment.

The Original Vouchers and stamped receipts for the above mentioned statement of Accounts are retained in College / Institute office and will be made available to University as when required.

Date: 03/11/2017

Place: Lonavala

Dr. Prashant S. Patil
Name & Sign. of
Prin. Investigator

College Seal

Dr. M. S. Gaikwad
Name & Sign. of Principal
PRINCIPAL
SINHGAD INSTITUTE OF TECHNOLOGY
Kusgaon (Bk.), Lonavala-410 401.

Chartered Accountant
Sign., Seal & Regn. No.

SATISH NIVRUTTI SATHE
MEMBERSHIP NO. 152548
CHARTERED ACCOUNTANT

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Kusgaon (Bk.), Lonavla-410401

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STATEMENT OF EXPENDITURE

Name of the College : **Sinhgad Institute of Technology, Lonavala**

Name of the Principal Investigator : **Dr. Prashant S. Patil**

A) RECEIPT: -

Total grants Sanction for Two years **Rs. 2,30,000/-**

Research Grant received **Rs.1,15,000 /-** towards the 1st Installment from

Savitribai Phule Pune University Vide letter No.: Finance/2016-17/1701 Dated: 22/11/2016		
Ch. No.300930	Date: 19/11/2016	Amount Rs. 4,27,500/-

B) EXPENDITURE :

Sr. No.	Particulars	Budget Provision	Exp. Amt. in Rs.
1	Equipments (Annexure – I)	35000/-	24629.50/-
2	Books & Journals (Annexure – II)	5000/-	NIL
3	Chemical & Consumables (Annexure – III)	30000/-	72672.92/-
4	Hiring Services (Annexure – IV)	10000/-	NIL
5	Field Work & Travel (Annexure – V)	10000/-	4310/- 2810/-
6	Contingency (Annexure – VI)	25000/-	4444/- 3189/-
	TOTAL	115000/-	106056.42/-

chemical held 2nd year मध्ये 60,060/-

Rs. 103201/-
Rs. 90628=50

C) Unspent Balance / (-) Excess Expenditure **Rs. 8944/-**.

Dr. Prashant S. Patil
Name & Sign. of Prin. Investigator

SINHGAD INSTITUTE OF TECHNOLOGY LONAVALA

College Seal

Dr. M. S. Gaikwad
Name & Sign. of Principal

PRINCIPAL
SINHGAD INSTITUTE OF TECHNOLOGY
Kusgaon (Bk.), Lonavala-410 401.

Chartered Accountant
Sign., Seal & Regn. No.

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Sinhgad Institutes

SINHGAD TECHNICAL EDUCATION SOCIETY'S

SINHGAD INSTITUTE OF TECHNOLOGY

(Affiliated to Savitribai Phule Pune University & Approved by AICTE)

Gat No. 309/310, Kusgaon (BK.), Off Mumbai - Pune Express way, Lonavala, Dist Pune - 410 401.

PROF. M. N. NAVALE	DR. (MRS.) SUNANDA M. NAVALE	DR. M. S. GAIKWAD
M E (Elect.) MIE, MBA	B A, MPM, Ph D	M E, Ph D (Electronics Engg.)
Founder President	Founder Secretary	Principal

Ref. No. SIT/2016-17/4663

Date:-03/11/2017

To,
The Director,
BCUD,
Savitribai Phule Pune University, Pune

Sub: Submission of audited BCUD research project first year report of University research grant scheme. (Letter No. and Date: **OSD/BCUD/392/197 Dated 11/11/2016**).

Ref: Your office circular No.: 265 dated 30/10/2017.

Respected Sir,

I undersigned, Dr. Prashant S. Patil have been sanctioned BCUD research project under SPPU, Pune, research scheme (Sanshodhan) with a grant of Rs. 2,30,000/- (Two Lakhs Thirty Thousand Rupees only). Vide SPPU letter **OSD/BCUD/392/197 Dated 11/11/2016**.
The title of my research project is "**Preparation, Characterization and Application of Nanocrystalline Multilayer Transparent Oxide Thin Films**".
I am submitting herewith the auditing financial report with progress report of research work done in for first year in prescribed proforma of Savitribai Phule Pune University.

You are requested to accept the same and release the remaining amount to complete the research in a given time.

Thanking You.

(Dr. Prashant S. Patil)
Principal Investigator

(Dr. M.S. Gaikwad)
Principal

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Annexure-I

UNIVERSITY OF PUNE

University with Potential for Excellence

FORMAT FOR SUBMISSION OF PROPOSAL FOR RESEARCH PROJECT

PART – A

1. Broad Subject: Physical Sciences Faculty : Engineering Sciences

2. Area of Specialization: Solar Photo-catalysis

3. Duration: 2 Years

4. Principal Investigator:

i) Name: Dr. Prashant S. Patil
ii) Sex: Male
iii) Date of Birth: 13/11/1974
iv) Qualification: M.Sc. Ph.D. (Physics)
v) Designation: Asst. Professor
vi) Address:

Office: Sinhgad Institute of Technology, Off Mumbai Pune Express way Kusgaon (Bk), Lonavala-410 401.

Residence: Flat No. 5, Gauravi Appartement Balewadi Phata, Chakankar Mala, Baner, PUNE-45

5. Name of the Institution where the project will be undertaken:
Sinhgad Institute of Technology, Off Mumbai Pune Express way Kusgaon (Bk), Lonavala-410 401

a. Department: Applied Sciences
b. University/College: University of Poona

6. Teaching and Research Experience of Principal Investigator

a. Teaching experience: 02 Years
b. Research experience: 06 years
c. Publication:
Papers Published: 05

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Part B

Proposed Research work

7. i) Project Title

Preparation, Characterization and Application of Nanocrystalline Multilayer Transparent Oxide Thin Films.

ii) Introduction

Energy is the lifeline of civilization. With the tremendous growth of science and technology and its consequent impact on industrialization, population growth has significantly increased. Consequently the energy demand for today, world's 90% of the energy is derived from fossil fuel (Pachauri and Sridharan, 1998). However fossil fuel has resulted into gigantic proportions of pollution. Moreover, the fossil fuel is depleting very rapidly. Hence all over the world scientists are in search of alternative sources of energy. Amongst various alternative sources, solar energy is considered to be the most viable option due to its abundance, environmental friendliness and free availability.

Heterogeneous Photo-catalysis is a technology based on UV irradiation of a semiconductor photo-catalytic compounds such as Titanium dioxide (TiO_2), Zinc oxide (ZnO), Tungsten oxide (WO_3), Indium tin oxide (ITO), Vanadium Oxide (V_2O_5), cadmium Sulphide (CdS) etc. [3,5,9,11,15]. When irradiated with light having sufficient energy (hv), semiconductor particle becomes part of a particulate system capable of photo-electrochemical cell at which efficient oxidation and reduction process may takes place [2]. Oxidation process has potential to oxidize almost all types of organic chemicals containing in industrial and domestic waste water (pesticides, organic solvents, surfactants, dyes).

However, among above mentioned catalysts, TiO_2 is considered to be the best option because of following reasons;

1. Carey et al. first demonstrated the use of TiO_2 in water detoxification in 1976. They showed that polychlorinated biphenyls (PCB) were de-chlorinated in aqueous suspensions of TiO_2.

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2. TiO_2 is the most commonly used photo-catalyst now-a-days in air and water purification processes. Near ambient temperature TiO_2 offers some distinct advantages such as photochemical stability against photo-corrosion, wide range pH applicability, low cost, non-toxicity and eco-friendliness. [1].
3. TiO_2 has a higher relative activity as compared to other alternatives. Many organic compounds have oxidation potential above that of the TiO_2 valence band and therefore can be oxidized by TiO_2. By contrast, TiO_2 can reduce only few organic compounds which have reduction potential below that of the TiO_2 conduction band [1].
4. TiO_2 is the most popular semiconductor because of its resistivity to strong acids and bases and its stability under UV illumination. Although, ZnO has similar band-edge position to those of TiO_2, but it is less desirable due to photo corrosion induced by self-oxidization [2].

- **Origin of the research problem**

Many investigations, using various kinds of TiO_2 photo-catalyst, have been actively carried out to address environmental concerns and there are no limits to the possibilities and applications of TiO_2 as ***"Environmentally Harmonious Catalyst"***. [6,7,8,10,14].

The efficiency of the photo-catalysis process is mainly determined by five factors

i. Efficient absorption of light with minimum entropy production.
ii. Fast charge separation after light absorption.
iii. Separation of charged species (e^- and hole$^+$) in order to prevent reverse reaction.
iv. Adjustment of the redox potentials of the excited states to the redox potential of organic pollutant.
v. Long-term chemical stability and continuous reproduction of charge species.

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However, TiO_2 does not allow the use of visible light, unlike plant photosynthesis, makes use of only 5-6% of the solar beam that reaches to the earth surface. Therefore, the development of clean and safe photo-catalytic system which can be applied to treat very large, global scale will only be depend on design and development of photo reactors with modified photo-catalyst which can be operate under visible light.

To overcome this limitation, dye sensitization of TiO_2 with metals such as Platinum, Tungsten, Iron etc. has been tried to improve the effectiveness of TiO_2 and also with zeolites loaded TiO_2 and activated carbon mounted TiO_2 [4,8].

As generally observed TiO_2 is an efficient photo-catalyst but most of the studies related to photo-degradation have been carried out using the suspension of TiO_2 powder in aqueous solution. However, the use of aqueous suspension is limited for practical application by filtration problems due to the small size of TiO_2 particle.

Alternatively, the catalyst can be deposited on to a suitable solid inert support, which eliminates the need of removing the catalyst. Unfortunately, available surface area for the reaction since the catalyst must adhere to the solid support and the reactor design is limited by the optical absorption constraints. Generally, a commonly used process of deposition involves the use of expensive precursor of TiO_2 in the form of sol-gel and thermal treatment of the film between 400 to 500 °C.

Properties of the thin films strongly depend on deposition methods such as Sol-Gel, Spray Pyrolysis, CVD, PECVD, Evaporation, Sputtering etc. However, Sol-Gel, Spray Pyrolysis is one of the most utilized methods to prepare desired properties of TiO_2 thin films with well-controlled process parameters such as gas flows, substrate temperature concentration of the solvent and solute substrate materials etc. Therefore, it is necessary to investigate the influences of the process conditions on the properties of deposited thin films. There is limited number of references available on TiO_2 and doped TiO_2 deposited by Sol-Gel, Spray Pyrolysis [12, 13].

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Considering the limitations of TiO_2, in visible optical region, for photo-catalytic applications; I would like to formulate followings aims and objective for the present proposal.

- **Interdisciplinary Relevance**

Solar Photo-catalysis is the branch of sciences and technology which involves the physicist, chemist, environmentalist and Engineers as this stream of science is highly interdisciplinary.

- **Review of Research and Development in the Subject** :

Gopalrao first reported internationally similar work in 1939 (Wang et al, 1994) when he was studying the photo-degradation of ammonia using titania colloids. After that, such a work for specific application to oxidation of cyanide and sulfite in aqueous solution was reported by Frank and Bard (1977). They used various semiconductors and compared their activities and stabilities. Some important work continued to be done in 80's (Okamato et al 1985a, 1985b; Smotkin and Bard 1986). Obviously the stress was more on knowing the process and photo-catalyzed intermediates for a given pollutant.

In 90's the interest in this area has grown manifold and a lot of research work on the parametric dependence of the process for various kind of pollutants and their combinations have been reported. Research on the engineering designs of the systems also started and has been reported. Such work are mainly being done at SERI, Golden CO (Blake et al, 1991), Solar Energy and Energy Conversion Laboratory, University of Florida, FL (Goswami et al 1992, 1998) and Sandia National Labs, NM, USA (Alpert et al 1991) Platforma Solar de Almeria, Spain and University of Barcelona (Curco D. et al 1996). Looking at the enormous potential of the process many kinds of reactor designs an methodologies are being proposed (March et al 1995; Curco D. et al 1996; Goswami 1999).

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- **International status**

A great deal of research work is going on all over the world that has been highlighted in above paragraphs also. Following are the selected references related to the present work:

Many studies are now concentrating on developing methods and systems to utilize the solar insolation more fruitfully (Rodriguez et al 1996; Nogueira et al 1996). Photo-catalytic degradation of phenol over TiO_2 was carried out by Okamoto K. et al (1985a) and its kinetics was also studied by Okamoto K. et al (1995b). He investigated the effect of initial concentration of phenol, pH, and effect of TiO_2 stirring on degradation rate. He observed that the anatase TiO_2 powder followed first order reaction kinetic, in which the apparent rate constant k_{app} depended on initial concentration of phenol and incident light intensity *I*. Degradation of phenol is not a single step process, during the degradation of phenol some intermediate products are formed at initial stage of the reaction such as pyrocatechol, hydroquinone, 1,2,4 -benzenetriol are observed. The photo-catalytic degradation of phenol using TiO_2 suspension has been studied at pilot plant scale with solar radiation at the Platform Solar de Almeria (PSA), Spain and at the laboratory level with Xenon lamp at the university of Barcelona (Curco D. et al 1996). Two different types of reactors were tested at PSA; high concentrating radiation systems (Heliomons) and low concentrating systems Compound Parabolic Concentrators (CPCs). The kinetic constants have been determined and compared for all the systems tested at pilot plant and laboratory scale and efficiency of the systems were reported.

- **National Status**

Most of the work on water splitting is done using UV radiation. However UV fraction is very less in solar spectrum. Using artificial UV source for energy production can never be economically viable. Hence scientists are working to drive the reaction with visible radiation. Use of appropriate catalyst and catalyst stimulator can shift the reaction to be driven by visible radiation.

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This technology is at nascent stage. Due to its relevance and scope, researchers all over the world are engaged in this field. It is an area of interdisciplinary work. Scientists of diverse discipline are working in collaboration with each other in this field. Earlier the UV radiation was found to be effective to drive the reaction of water split up. However due to its limited availability in terrestrial solar spectrum, the emphasis during 80s was to make the reaction driven by visible radiation (Gerisher 1972). The process involves a large number of variables to be optimized. There is ample scope for process optimization. Several parameters need to be accounted. In India Few groups were working on this field such as Dept. of Physics, University of Poona, Dept. of Energy, Tezpure central university, Assam, C-MET Pune, UDCT, Mumbai.

- **Significance of the study**

As seen in the literature review, photo-catalysis is a newly discovered horizon in the field of wastewater (and air pollution) treatment. It requires optimization of parameters. The process is heterogeneous in nature and involves a large number of parameters. The optimization of any single parameter is valid only in the limited range of other parameters. Hence it requires regressive research studies to be carried out to develop the "sets of optimum range of variables". As the range of organic pollutants of concern is also quite vast the scope of study also becomes very vast. The present proposal is another linkage in this string. The present study emanates on objectives:

First, to developed a suitable method for deposition of oxide materials so that we can apply deposited thin films effectively for performance testing of organic decomposition. Second, to compare the relative effectiveness of prepared thin oxide films on the basis of actual performance for degradation of selected probe chemical. Third, to evolve the concept of average photonic efficiency of the photo-catalysis and to estimate it for the reactions under study. Such a study for photo-catalytic degradation of dyes is will be undertake first time. One more objective of the present work is couple up the photo-catalysis with photo-thermal conversion, because both of these use solar energy. Photo-

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catalysis requires only a small fraction of the total energy of solar spectrum i.e. the energy in the wavelength range of 300 to 380 nm, which is only 5% of the overall energy of the spectrum. Remaining energy is unused. Hence it necessitates to design a system which utilizes the 300 to 380 nm fraction of radiation for photo-catalysis and the remainder for photo-thermal. Such a system finds applications in industries and will be saving significantly the land requirements.

iii) **Objective of the present proposal:**

1. To deposit TiO_2 thin film by sputtering (either DC/RF).
2. Deposition of other oxide materials like WO_3, CuO, ITO, SnO_2 etc by sputtering and to explore the possibilities of their use for the same application.
3. To prepare multi-layers / bi-components of TiO_2, SnO_2, ITO, etc. oxides materials.
4. To modify electrical and optical properties of TiO_2 by doping transition metals for larger absorption of solar spectrum.
5. To study the catalytic properties of the prepared thin films for detoxification of waste water, mineralization of bacterial cell etc.
6. To improve photo-induced super-hydrophilic properties of TiO_2 and doped TiO_2 thin films.
7. Preparation of nano-composites thin film of TiO_2 with Al_2O_3, V_2O_5 etc.
8. Laboratory experiments for photo-catalytic degradation process will be carried out and results will be scale up for pilot plant level.

iv) **Methodology adopted to work out the proposal**

a. **Deposition methods**

Deposition of the oxide thin films proposed in aims and objectives will be done by Sputtering or whichever will be possible within the scope of the project.

b. **Characterization methods**

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Experimental characterizations of the pollutant will be done by UV-Visible spectroscopy, FTIR, HPLC, GC, TOC etc. The photon flux will be measured by UV pyranometer and radiometer. Characterizations of the oxide thin film will be done by using SEM, TEM, XPS, Raman spectroscopy, contact angle measurement, photoluminescence etc. The Crystalline structure and phase of the film will be characterized using X-ray diffraction (XRD). The particle size will be determine by using N_2 adsorption-desorption isotherm. Optical transmittance spectra of the film will be determined by UV-Vis-NIR spectrophotometer. Mechanical properties will be characterized by suitable methods. Ellipsometry will be used to determine thickness and refractive index of thin films.

c. Performance Testing

Performance of deposited oxide thin film will be carried out by using Photo-catalysis process by evaluating quantum yield.

v) **Year wise Plan of work and targets to achieve**

Sr No	Activity	Duration In months
1	First phase procurement of literature and study	0 – 3
2	Outline methodology, Procurement of required chemicals	3 – 6
3	Preparation of thin films by different methods, under parametric variation	6 – 12
4	Characterization of thin films	12 – 15
5	Performance testing of thin films for detoxification	15 – 20
6	Result analysis, selection of best material and method	20 – 24
7	Repeated experimentations with selected material	24– 26

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vi) **Details of collaboration, if any intended**

For Characterization of thin films such as SEM,XRD, FTIR and materials prepared by spray pyrolysis and sol-gel method we will use the facility of University of Poona, C-MET Pune, NCL, Pune and School of Physical Sciences, NMU, Jalgaon.

8. Financial Assistance required (First & Second Year Consolidated)

Sr No	Item	Estimated Expenditure In Rs.
1	Hiring Services	20,000/-
2	Field Work and Travel	30,000/-
3	Chemicals and glassware	60,000/-
4	Contingency (including special needs) Characterization charges	50,000/-
5	Books and Journals	15,000/-
6	Equipment, if needed	
	1.UV Bulbs of 125 W each & Sonicator	25,000/-
	2. Centrifuge Machine	15,000/-
	3. Electronic Balance	30,000/

Total in Rs. 2,45,000/- (Rs. Two Lakhs forty five thousand only)

9. (a) Details of the project/scheme completed with the P.I

Name of the Agency	Sanction Year	Total in Rs.	Equipment/Infrastructural facilities obtained
DST, New Delhi	2007	379000	Photochemical reactor & High Temp. Furnace

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(b) **Institutional and Departmental facilities available for the proposed work**

Equipment:

Signal pan balance, Furnace up to 700^{0}C, UV-Visible spectrometer, distilled water plant etc.

Other Infrastructural facilities:

All basic requirements needed to execute project such as space, water, electricity, library, computer with internet facility etc. will be provided by host institute.

10. Any other information which the investigator may like to give in support of this proposal which may be helpful in evaluating.

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References

1. A. Comite, A. Sorrentino, G. Capannelli, M. Di Serio, R. Tesser, E. Santacesaria (2003) Oxidative dehydrogenation of propane using $V_2O_5/TiO_2/SiO_2$ catalysts prepared by grafting titanium and vanadium alkoxides on silica. J. of Mole. Catal. A: Chemical 198, 151-165.
2. A. Cooper, D.Y. Goswami (1998) Solar photochemical detoxification for water treatment in tropical developing countries. J. Adva. Oxid. Tech. Vol.3 (2) 151-154
3. A. Cooper, D.Y. Goswami (June 1998) A survey of solar based drinking water treatment. Proceeding of the ASME international solar energy conference, Albuquerque, New Mexico, 265-275.
4. A. R. Phani, S. Santucci (2001) Structural characterization of iron titanium oxide synthesized by sol-gel spin-coating technique. Materials Letters 50, 240-245.
5. A. T. Kooper, D.Y. Goswami (2002) Evaluation of methylene blue and rose Bengal for dye sensitized solar water treatment. J. solar energy engineering vol.124, 305-310.
6. A. Vidal, Z. Dinya, F. Mogyorodi Jri., F. Mogyorodi (1999) Photocatalytic degradation of thiocarbamate herbicide active ingredients in water. Appl.Catal. B:Environ. 21, 259-267.
7. A.T. Cooper, D.Y. Goswami, S. S. Block (April 1997) Simultaneous detoxification and disinfection of water by solar photocatalytic treatment. Solar engineering 1997, proceeding of the ASME international solar energy conference, Washington, D.C.
8. Aihua Wang, Jimme G. Edwards, Julian A. Davies (1994) Photooxidation of aqueous ammonia with tatania-based heterogeneous catalysis. Solar energy vol.52 (6), 459-466.
9. Akira Fujishima, K Honda , 1972 electrochemical photocatalysis of water at semiconductor electrode , Nature, 238, 37-38

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Part-C

Declaration

To certify that:

a). General physical facilities, such as furniture/space etc., are available in the Department/College.

b). I/we shall abide by the rules governing the scheme in case assistance is provided to me/us from the University of Pune for the above project.

c) I/we shall complete the project within the stipulated period. If I/we fail to do so and if the University of Pune is not satisfied with the progress of the research project, the University of Pune may terminate the project immediately and ask for the refund of the amount received by me/us.

d) The above Research Project is not funded by any other agency.

Name and Signature

(Patil Prashant S.)
Principal Investigator

Name and Signature

(Waghmare M. A.)
Co- Investigator

Academic & Research Co coordinator

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