Shetkari Shikshan Prasarak Mandal's

Krishna Mahavidyalaya, Rethare Bk

IQAC 2019-2020

ACTIVITY REPORT
PHYSICS DEPARTMENT

IQAC ACTIVITY No:

NAME OF THE ACTIVITY: "Lead college Activity-Research Project: "Synthesis and characterization of WO_3 thin film by sol gel method for smart window application."			
DATE	**FACULTY**	**DEPARTMENT/COMMITTEE**	**COORDINATOR NAME**
Throughout the academic year	Science	Physics	Dr. Dhanaji S. Dalavi
TIME	**VENUE**	**NUMBER OF PARTICIPANTS**	**NATURE: Outdoor/Indoor**
	Physics laboratory	04 students+01 teacher	Indoor
SUPPORT/ASSISTANCE:	Nil		

BRIEF INFORMATION ABOUT THE ACTIVITY (**CRITERION NO. -**):

TOPIC/SUBJECT OF THE ACTIVITY	**"Lead college Activity-Research Project: "Synthesis and characterization of WO_3 thin film by sol-gel method for smart window application."**
OBJECTIVES	to analyze a scientific occurrence with an investigation or to solve a problem with an invention.
METHODOLOGY	Experimental work
OUTCOMES	students become active, engaged learners. It also helped students to develop independent critical thinking skills.

PROOFS & DOCUMENTS ATTACHED (Tick mark the proofs attached):

1. Notice & Letters	2. Student list of	3. **Activity report**	4. **Photos**	5. Feedback form
6. **Feedback analysis**	7. News clip with details	8. Certificate	9. Any other	10.

IQAC CELL ACTIVITY NUMBER:

NAME OF TEACHER & SIGNATURE	NAME OF HEAD/ COMMITTEE INCHARGE & SIGNATURE	PRINCIPALS SIGNATURE	IQAC COORDINATOR (SEAL & SIGNATURE)
Dr. Dhanaji S. Dalavi	Dr. Dhanaji S. Dalavi		

HEAD
DEPARTMENT OF PHYSICS
KRISHNA MAHAVIDYALAYA,
Rethare Bk; Shivnagar - 415108

Principal
Krishna Mahavidyalaya, Rethare Bk,
Tal. Karad ; 415 108 (MS)

IQAC, Coordinator,
KRISHNA MAHAVIDYALAYA,
Rethare Bk; Shivnagar - 415108
Tal. Karad, Dist. Satara

"Education through self-help is our motto." - Karmaveer

रयत शिक्षण संस्था, सातारा 1919-2019

शताब्दी महोत्सव

Rayat Shikshan Sanstha's

Estd.: 1954

SADGURU GADAGE MAHARAJ COLLEGE, KARAD

VIDYANAGAR, Pin - 415 124, Dist. Satara (M.S.) INDIA P.O. Box No.3
Ph. Office : (02164) 271346 Resi. (02164) 271794 **Fax.** (02164) 271346
Website : www.sgm.edu.in **E-mail :** sgmkarad@yahoo.com

ARTS, SCIENCE, COMMERCE & VOCATIONAL (Junior & Senior)

Jr. College No. j.21.02.003 **(Affiliated to Shivaji University, Kolhapur)**

Accredited **A+** with **CGPA 3.63** by NAAC **ISO 9001 : 2015 Certified College**

Principal : Dr. Mohan Rajmane M.Sc., Ph.D.

Ref. No. 1689/19-20

Date : 01/ 11/ 2019

To

The Principal,
Krishna Mahavidyalaya Rethare (Bk.)
Tal.Karad, Dist. Satara.

Sub. : Submission of Research Project under Research Promotion Activity ofr College Students.

I am pleased to inform you that the Research Project under the Research Promotion Activity of the Shivaji University, Kolhapur is received with following details.

Name of Project Advisor	Name of Students	Title of Project	Amount Estimate Rs.
Dr. D. S. Dalavi	1) Lad Divya Dilip 2) Mohini Rajendra Harale 3) Ashlesha Arun Patil 4) Aniket Anil Dmame	Synthesis, Characterization of WO3 thin film by sol-gel route for electrochromic smart windows application. .	10,000/-

Financial assistance under this scheme is subject to final approval and directions of the university.

Thank you,

Yours faithfully,

Principal,
Lead College,
Sadguru Gadage Maharaj College,
KARAD

Dr. Dalavi D.S.
07/11/19

ापना : १९५४

"स्वावलंबी शिक्षण हेच आमचे ब्रीद" –कर्मवीर

रयत शिक्षण संस्थेचे,

सद्गुरू गाडगे महाराज कॉलेज, कराड

स्वायत्त महाविद्यालय – शिवाजी विद्यापीठ, कोल्हापूर संलग्नित

विद्यानगर, कराड पिन – ४१५ १२४ जि. सातारा (महाराष्ट्र) पो. ऑ. बॉ. नं. ३

फोन : कार्यालय : (०२१६४) २७१३४६ फॅक्स : (०२१६४) २७१३४६

Website : www.sgm.edu.in E-mail : sgmkarad@yahoo.com

कला, विज्ञान, वाणिज्य व व्यवसाय शिक्षण (कनिष्ठ व वरिष्ठ)

नॅक मानांकन : A^+ CGPA 3.63 • आयएसओ प्रमाणित कॉलेज : 9001 : 2015

Jr. College No. j.21.02.003

ाचार्य :
ॉ. मोहन राजमाने
एम.एससी., पीएच्.डी.

संस्थापक

पद्मभूषण
डॉ. कर्मवीर भाऊराव पाटील
डी.लिट.

संदर्भ क्र. : 2269/19-20 **REGISTERED AD** दिनांक : १७/०२/२०२०

प्रति,

मा.प्राचार्य,
कृष्णा महाविद्यालय, रेठरे बु ।।
जि.सातारा

विषय : अग्रणी महाविद्यालय योजनेअंतर्गत रिसर्च प्रोजेक्टसाठी द्यावयाच्या ॲडव्हान्सबाबत.

महोदय,

शिवाजी विद्यापीठाच्या Research Promotion Activity for students of the affiliated Colleges या योजनेअंतर्गत आपल्या विद्यार्थ्यांच्या "Synthesis Characterization of WO3 thin film by sol-gel route for electrochromic smart windows application" या रिसर्च प्रपोजलसाठी विद्यापीठाने रू. १००००/- मंजूर केले असून सदर ॲडव्हान्स रकमेचा चेक नं. 960393 दि. १८/०२/२०२० ने सोबत पाठविला आहे. कृपया सदर रकमेची पोहोच पावती त्वरीत पाठवून द्यावी.

वरील रिसर्च प्रोजेक्टसाठी मंजूर रक्कम रू.१०,०००/- खर्च करून त्याचा हिशोब व प्रोजेक्ट रिपोर्ट या अग्रणी महाविद्यालयाकडे त्वरीत सादर करावा.

कळावे, ही विनंती.

आपला विश्वासू,

प्राचार्य,
अग्रणी महाविद्यालय
सद्गुरू गाडगे महाराज कॉलेज, कराड

SADGURU GADAGE MAHARAJ COLLEGE KARAD

सोबत : वरीलप्रमाणे.

24/2/2020
Lead college
Res. project
Dr. Dalavi
Phy.

Krishna Mahavidyalaya, Shivnagar
Inward No.- 1357
Date- 25/02/20.

NVGaikwad. Sir.

संहती कार्यसाधिका । शिलं परं भूषणम्

Shetkari Shikshan Prasarak Mandal's

KRISHNA MAHAVIDYALAYA, RETHARE BK.

Shivnagar, Tal. Karad, Dist. Satara, 415108 (M.S.)

Email : kmr_sspm@yahoo.co.in Website : www.krishnamahavidyalaya.com

NAAC 'B+' Grade (CGPA 2.65)

Principal (I/C) : Dr. Salunkhe C. B., M.Sc., Ph. D. Founder : Hon. Jaywantrao Bhosale

Ref. No. : KMR/313/2019-2020 Date : 03-03-2020.

प्रति,
मा. समन्वयक
अग्रणी महाविद्यालय
सदगुरू गाडगे महाराज कॉलेज
कराड जि. सातारा.

विषय :- अग्रणी महाविद्यालया अंतर्गत राबवलेल्या रिसर्च प्रोजेक्टच्या खर्चाचा अहवाल.

महोदय,

शिवाजी विद्यापीठाच्या Research Promotion activity for students of the affiliated collages या योजनेअंतर्गत या महाविद्यालयातील विद्यार्थ्यांच्या "Synthesis, Characterization of WO_3 thin film by sol-gel route for electrochromic smart windows application" या रिसर्च प्रोपोसलं साठी विद्यापीठाने रु. १०,०००/- मंजूर केले होते सदर रिसर्च प्रोपोसलं साठी आपणाकडून रु. १०,०००/- चे ॲडव्हान्स रकमेचे चेक नं 107313 दि. 18/02/2020 रोजी मिळाला असून त्यानुसार वरील रिसर्च प्रोजेक्टसाठी मंजूर रकमेच्या खर्चाचा तपशील व अहवाल आपणाकडे पाठवत आहे

खर्चाचा तपशील खालीलप्रमाणे.

अ.नं	तपशील	साहित्य	खर्च
१.	Shri. Samarth Trading Company	Chemicals	7500.00
२.	Bhadi and Company	Stationary	154.00
३.	Chingale Surgicals	Stationary	1030.00
४.	Dhiraj Stationers	Stationary	684.00
५.	Anushka Stationers	Stationary	654.00
६.	Uma Xerox	Xerox	25.00
		Total	10,047=00

Received
[signature] 12/3/20

समन्वयक

[signature]
Principal
Krishna Mahavidyalaya, Rethare Bk.
Tal. Karad · प्राचार्य (MS)

FORMAT FOR STATEMENT OF EXPENDITURE

1. **SUK file No:** SGM/1689/2019-2020 dated 01/11/2019
2. **Title of the Lead college Project:** "Synthesis, Characterization of WO_3 thin film by sol-gel route for electrochromic smart windows application".
3. **Name of the Project Advisor:** Dr. Dhanaji S. Dalavi, Physics.
4. **Number of students participated in the project:** 04
5. **Duration of the Activity:** July 2019 to March 2020.

Sanction No. and date	Grant sanctioned	Details of expenditure incurred item wise		Amount
SGM/1689/2019-2020 dated 01/11/2019 & SGM/2289/2019-2020 dated 17/02/2020 Advance cheque No. 107313.	**10, 000/-**	Shri. Samarth Trading Company	Chemicals	7500.00
		Bhadi and Company	Glass cutter	154.00
		Chingale Surgicals	Stationary	1030.00
		Dhiraj Stationers	Stationary	684.00
		Anushka Stationers	Stationary	654.00
		Uma Xerox	Xerox	25.00
			Total Expenditure	**10, 047.00**
			Grant Received	**10,000.00**

It is certified that the sanctioned amount of Rs. 10,000/- (Rupees Ten thousand only) out of the total grant of Rs. 10,000/- (Rupees Ten Thousand) has been received for the project work to the Department of Physics, Krishna Mahavidyalaya, Rethare (Bk) by the Shivaji University, Kolhapur. its Letter No. SGM/2289/2019-2020, **cheque No. 107313. dated 17/02/2020** has been utilized for the purpose for which it was sanctioned and in accordance with the terms and conditions laid down by the Shivaji University, Kolhapur.

27/2/2020

Principal
Krishna Mahavidyalaya, Rethare Bk
Tal. Karad 415108 (MS)

Project Advisor

Dr. Dhanaji S. Dalavi

Dr. Dhanaji S. Dalavi
Assistant Professor (Physics)
Krishna Mahavidyalaya
Rethare (Bk), Tal. Karad

Principal

UTILIZATION CERTIFICATE

Certified that the Rs.10,000/- (Ten Thousand Only) has been sanctioned by the Shivaji University, Kolhapur to couduct the lead college Project entitled **"Synthesis, Characterization of WO_3 thin film by sol-gel route for electrochromic smart windows application".** on 2019-2020 has been incurred by the observing scrupulously all the rules and as per rates prescribed by the Shivaji University, Kolhapur.

The unspent balance of Rs. **Nil** is refunded to the Shivaji University, Kolhapur wide challan dated---------- in the bank -------------- in A/C No--------- receipt No.-------dated----------

The excess expenditure of Rs. **Nil** over the advance is receivable from Shivaji University, Kolhapur.

The expenditure incurred of **Rs. 10, 047** out of which **Rs. 10,000/-** has been received wide cheque **No. 107313. dated 17/02/2020** and remaining Rs.**Nil** is receivable from Shivaji University, Kolhapur.

The penal interest of Rs. **Nil** is credited to the University, vide receipt No.-------dated------ under the budget head A.4.R.2.

Certified that the original vouchers, bills and stamped receipt for the above mentioned of A/C are retained in this office and will be made available as and when required.

Place: Shivnagar

Date:

Project Advisor

Dr. Dhanaji S. Dalavi

Dr. Dhanaji S. Dalavi
...ssor (Physics)
Kri... ...vidyalaya
Rethare ... Tal. Kara...

Principal
Krishna Mahavidyalaya, Rethare Bk.
Tal. Karad ... 415108 (MS)

Principal

Dr. Dhanaji S. Dalavi,
Assistant Professor
Department of Physics,
Krishna Mahavidyalaya,
Rethare (Bk).
Date: 27/02/2020

To,

The Principal,

Krishna Mahavidyalaya, Rethare (Bk)

Shivnagar-415108

Subject: Submission of Bills toward purchase of chemicals and Glassware under lead college Activity research project.

Respected Sir,

With reference to above mentioned subject, we have purchased chemicals and glassware through Research Promotion activity for students of the affiliated college initiated by Shivaji University, Kolhapur for the research project entitled **"Synthesis, Characterization of WO_3 thin film by sol-gel route for electrochromic smart windows application".**

Herewith I kindly request you to issue check of Rs. 7,500/- in favour of **Shri. Samarth Trading Company, Islampur** toward the purchase of chemicals and glassware's.

Thanking You

Yours Faithfully

27/2/2020

Principal
Krishna Mahavidyalaya, Rethare Bk
Tal. Karad 415108 (MS)

Project Advisor
Research Promotion Activity

Dr. Dhanaji S. Dalavi
Assistant Professor (Physics)
Krishna Mahavidyalaya,
Rethare (Bk.), Tal. Karad

Ref.

To,

Department Physics

Date— 19-1-2020

The Principal,

KRISHNA MAHAVIDYALAYA, SHIVNAGAR

Subject– Request to pass the bills for payment,

Sir,

Please find herewith the following bills for the payment while passing the bills I have checked the price of each item and is according to the price quoted by the party.

Sr. No.	Name of the Firm	Bill No. / Date	Amount	Deductions if any	Net Paid
	Shri Samarth Trading Company Islampur-415409	CO 421 19-1-2020		–	7500=00
	Rs. Seven Thousand Five Hundred only				7500=00

Thanking you,

Lab / Assistant

---------- Department

KRISHNA MAHAVIDYALAYA, SHIVNAGAR

Yours faithfully,

HEAD

Head

DEPARTMENT OF PHYSICS

------ Department

KRISHNA MAHAVIDYALAYA

SHIVNAGAR 415108

GSTIN : 27AMVPP2791E1ZG

TAX INVOICE

SSTC Shri Samarth Trading Company

Peth Sangli Road, Opp. Ganesh Servicing Center, Shripadnagar, ISLAMPUR - 415 409
Tal. Walwa, Dist. Sangli. Tel. (02342) 225394, 225773 Mob. 9822256373
E-mail : samarth.trading@yahoo.com samarth4092@gmail.com

Original Buyer's Copy

voice No.:- CO/411/2019-20
oice date:-19/01/2020
verse Charge (Y/N):
te: Maharashtra

PO No.:-
Date :-15/01/2020

Code 27

Transport Mode:-
Vehicle number:-
Date of Supply :-
Challan No.:-

Bill to Party
me: The Principal, Krishna Mahavidyalaya
dress :-Rethare BK
:- Satara
IN:-
e:- Maharashtra
Code 27

Ship to Party
Name:-
Address:-
GSTIN:-
State:-
Code

Product Description	Make	GST	Qty	Rate	Amount	Discount	Taxable Value	CGST Rate	CGST Amount	SGST Rate	SGST Amount	Total
Cobalt Nitrate Hexahydrate AR 250gm	Loba	18%	1	2300.00	2300.00	1035.00	1265.00	9	113.85	9	113.85	1492.70
Cobalt Acetate AR 250gm	Loba	18%	1	2850.00	2850.00	1282.50	1567.50	9	141.08	9	141.08	1849.65
drochloric Acid 2.5 Lit	Loba	18%	1	780.00	780.00	351.00	429.00	9	38.61	9	38.61	506.22
Acetone AR 2.5 Lit	Loba	18%	1	1100.00	1100.00	495.00	605.00	9	54.45	9	54.45	713.90
Ammonia Solution 28-30% AR 2.5Lit	Loba	18%	1	620.00	620.00	279.00	341.00	9	30.69	9	30.69	402.38
Hydrogen Peroxide 35% AR	Loba	18%	2	450.00	900.00	405.00	495.00	9	44.55	9	44.55	584.10
Absolute Ethanol 99.9 % AR 500ml	China	18%	2	347.00	694.00	312.30	381.70	9	34.35	9	34.35	450.41
TO Conducting Glass Substrate (10x10)		18%	1	2313.00	2313.00	1040.85	1272.15	9	114.49	9	114.49	1501.14
Total			10		11557.00	5200.65	6356.35		572.07		572.07	7500.49

Total Invoice amount in words
Thousand Five Hundred Rupees Only.

Total Amount before Tax	6356.35
Add: CGST	572.07
Add: SGST	572.07
Total Tax Amount	1144.14
Total Amount after Tax:	7500.49
Round Off Total Amount	7500.00

Certified that the particulars given above are true and correct

Bank Details
C: 579505040000105 Bank Name : Union Bank of India
C: UBIN0557951 Branch : Islampur
tion :
are that this invoice shows the actual price of the goods
d and that all particulars are true and correct.
y GSTIN/UIN : 27AMVPP2791E1ZG
y PAN : AMVPP2791E

Shri Samarth Trading Company, Islampur Pin No. 415 409 (Sangli)
Common Seal

For SHRI SAMARTH TRADING COMPANY

Authorised signatory

Dr. Dhanaji S. Dalavi,
Assistant Professor
Department of Physics,
Krishna Mahavidyalaya,
Rethare (Bk).
Date: 27/02/2020.

To,

The Principal,

Krishna Mahavidyalaya, Rethare (Bk)

Shivnagar-415108

Subject: Submission of Bills toward purchase of contingency under lead college Activity research project.

Respected Sir,

With reference to above mentioned subject, we have purchased contingent items of Rs.2,547/- through Research Promotion activity for students of the affiliated college initiated by Shivaji University, Kolhapur for the research project entitled **"Synthesis, Characterization of WO_3 thin film by sol-gel route for electrochromic smart windows application"**. For the purchase of said items I have paid Rs. 2,547/-

Herewith I kindly request you to issue check of Rs. 2,547/- in favour of **Dr. Dhanaji Suresh Dalavi** toward the purchase of contingent items.

Thanking You

Yours Faithfully

Principal
Krishna Mahavidyalaya, Rethare Bk
Tal. Karad 415108 (MS)

Project Advisor
Research Promotion Activity
Dr. Dhanaji S. Dalavi
Assistant Professor (Physics)
Krishna Mahavidyalaya,
Rethare (Bk.), Tal. Karad

GST INVOICE

BHADI & COMPANY

BHADI

• *Hardware Merchant* •

H.O. : 31/32, Shaniwar Peth, KARAD - 415110 ☎ 222821

M/s. प्राचार्य कृष्णा महाविद्यालय रेठरे बुद्रुक

Party GST No. :

INVOICE No. 186

Date: 22/12/2019

Particulars	HSN Code	Qty.	Rate	Amount
रबरी कटर		1	130/-	130=00

Rs. in words one hundred fifty four only.

	Amount before Tax	130=00
9 %	Add : GST	11=70
9 %	Add : CGST	11=70
%	Add : IGST	153=40
	Round off	00=60
	Grand Total	154=00

GSTIN No. : 27AAUPB2903K1ZL
Bank of Baroda :
A/c No. 31090200000002
IFSC Code : BARBOKARADDX
Branch - Karad

Subject to Karad Jurisdiction

For BHADI & CO.

BILL OF SUPPLY
Cash Sale

NGALE SURGICALS
l,Opp. Popatbhai Petrol Pump, Shaniwar
N/UIN : 27AWSPC0007D1Z1
act : 7385406433

Invoice No.	Dated
CS 9	27/01/2020
Delivery No.	Dated

er
cipal krushna mahavidyalay rethre bk
d
N/UIN :

Description of Goods	HSN	Qty	Rate	Per	Amount
PLANE FORCEP	9018	5.00	80.00	NO	400.00
EXAM GLOVES L	40149	1.00	250.00	NO	250.00
COTTON 100 GM	0	6.00	45.00	NO	270.00
			Gross Amount		**920.00**
Round Off @ Sale					**0.40**
SGST(OUTPUT) 6%					**55.20**
CGST(OUTPUT) 6%					**55.20**
TOTAL =		**12.00**			**1,030.00**

panys Bank Details
k Name :- UCO BANK
No. :- 21710210001073
nch/IFSC Code :-KARAD / UCBA0002171
ds Once Sold Will Not Be Taken Back Or Exchanged.

Subject to KARAD Juridiction.

For CHINGALE SURGICALS
Chingale Surgicals
Authorised Signatory
Proprietor

"Composition taxable person not eligible to collect tax on supplies"

दि. 27/02/2020

कॅश–मेमो

रिज स्टेशनर्स

सोमवार पेठ, कराड, जि. सातारा

कृष्णा महाविद्यालय

वर्णन	नग	दर	रुपये	पैसे
—	2	180	360	00
मार्हिता	2	72	144	00
पर पार्मीट	1	–	180	
		एकूण –	684	00

Acc. Page – 1001

Order No. —— Date ——
Bill No. 2747 Date 27.2.20
Amount of bill Rs. 684/–
Deduction if any Rs.
Bill passed for Rs. 684/–

Salani
HEAD
DEPARTMENT OF PHYSI
KRISHNA MAHAVIDYALA
SHIVNAGAR 415108

No. 182 CASH MEMO Mob. 8600505861

UMA STORES & XEROX

Near Krishna Mahavidyalaya, Julewadi.Tal.- Karad, Dist. - Satara.

Shree Principle Krishna mahavidyalaya Rethare B.K. Date 05/11/2019

Description	Total	Rate	Amount Rs. Ps
xerox Paper	25	1	25
		Total-	25/-

Authorised sang.

Acc. Page 1001

Order No. —— Date ——
Bill No. 182 Date 5-11-19
Amount of bill Rs. 25/–
Deduction if any Rs.
Bill passed for Rs. 25/–

Salani
HEAD
DEPARTMENT OF PHYSICS
KRISHNA MAHAVIDYALAYA
SHIVNAGAR 415108

कॅश-मेमो

अनुष्का स्टेशनरी ॲन्ड जनरल स्टोअर्स

कार्वेनाका, कराड. मो. ९७६७२७११७२

श्री. कृष्णा महाविद्यालय रेठरे

दिनांक ०३ / ०२ / २०२० रा.

तपशील	नग	किमंत	रुपये
प्लास्टिक डबा	2	40	80/-
बाइंडर	4	20	80/-
टिशू पेपर	2	25	50/-
कटर	2	20	40/-
क्लीप	1	35	35/-
फेव्हीकॉल	1	45	45/-
फाईल	6	10	60/-
फेव्हीक्वीक	2	30	60/-
मार्कर CD	8	8	64/-
फोम टेप	3	20	60/-
फॉईल पेपर	1	80	80/-

अक्षरी रु. एकूण - 654/-

अनुष्का शालेय स्टेशनरी ॲन्ड जनरल स्टोअर्स
कार्वे नाका, कराड :९८८१५७६८७३

सही/शिक्का

Acc Page No 1000

Order No. .... Date........
Bill No. .... Date........
Amount of bill Rs. 654=00
Deduction if any Rs. ....
Bill passed for Rs. 654/-

HEAD
DEPARTMENT OF PHYSICS
KRISHNA MAHAVIDYALAYA
SHIVNAGAR 415108

UNIVERSITY, KOLHAPUR

RESEARCH SENSITIZATION SCHEME FOR COLLEGE STUDENTS

UNDER LEAD COLLEGE, ACTIVITY

SUBMISSION OF PROJECT REPORT

TITLE OF THE PROJECT: SYNTHESIS, CHARACTERIZATION OF WO_3 THIN FILM BY SOL-GEL ROUTE FOR ELECTROCHROMIC SMART WINDOWS APPLICATION.

BY

MISS. LAD DIVYA DILIP,

MISS. MOHINI HARALE RAJENDRA,

MISS. PATIL ASHLESHA ARUN,

MR. DAMAME ANIKET ANIL

UNDER THE GUIDANCE OF

DR. DHANAJI S. DALAVI

ASSISTANT PROFESSOR,

KRISHNA MAHAVIDYALAYA, RETHARE, BK

ACADEMIC YEAR: 2019-2020

UNIVERSITY, KOLHAPUR

RESEARCH SENSITIZATION SCHEME FOR COLLEGE STUDENTS

UNDER LEAD COLLEGE, ACTIVITY

SUBMISSION OF PROJECT REPORT

TITLE OF THE PROJECT: SYNTHESIS, CHARACTERIZATION OF WO_3 THIN FILM BY SOL-GEL ROUTE FOR ELECTROCHROMIC SMART WINDOWS APPLICATION.

BY

MISS. LAD DIVYA DILIP,

MISS. MOHINI HARALE RAJENDRA,

MISS. PATIL ASHLESHA ARUN,

MR. DAMAME ANIKET ANIL

UNDER THE GUIDANCE OF

DR. DHANAJI S. DALAVI

ASSISTANT PROFESSOR,

KRISHNA MAHAVIDYALAYA, RETHARE, BK

ACADEMIC YEAR: 2019-2020

DECLARATION

We hereby declare that, the project report entitled **"Synthesis, Characterization of WO_3 thin film by sol-gel route for electrochromic smart windows application"** submitted by us has been completed and written by us, has not previously formed and published in any other University in India or any other country or examining body to the best of our knowledge.

Place: Shivnagar

Date: 29/02/2019

Name of project students.

1. Lad Divya Dilip.
2. Patil Ashlesha Arun A·A·Patil
3. Mohini Harale Rajendra.
4. Damame Aniket Anil.

CERTIFICATE

This is to certify that thesis entitled **"Synthesis, Characterization of WO_3 thin film by sol-gel route for electrochromic smart windows application"** which is being submitted herewith is the result of original research work completed by **Miss. Lad Divya Dilip, Miss. Patil Arun Ashlesha, Miss. Mohini Harale Rajendra, Mr. Damame Aniket Anil** under my supervision and guidance and to the best of my knowledge and belief, the work embodied in this project work has not formed earlier.

Place: Shivnagar

Date: 29/02/2020

Project Advisor

(Dr. Dhanaji S. Dalavi)

UNIVERSITY, KOLHAPUR

RESEARCH SENSITIZATION SCHEME FOR COLLEGE STUDENTS

UNDER LEAD COLLEGE, ACTIVITY

SUBMISSION OF PROJECT REPORT

TITLE OF THE PROJECT: SYNTHESIS, CHARACTERIZATION OF WO_3 THIN FILM BY SOL-GEL ROUTE FOR ELECTROCHROMIC SMART WINDOWS APPLICATION.

BY

MISS. LAD DIVYA DILIP,

MISS. MOHINI HARALE RAJENDRA,

MISS. PATIL ASHLESHA ARUN,

MR. DAMAME ANIKET ANIL

UNDER THE GUIDANCE OF

DR. DHANAJI S. DALAVI

ASSISTANT PROFESSOR,

KRISHNA MAHAVIDYALAYA, RETHARE, BK

ACADEMIC YEAR: 2019-2020

DECLARATION

We hereby declare that, the project report entitled **"Synthesis, Characterization of WO_3 thin film by sol-gel route for electrochromic smart windows application"** submitted by us has been completed and written by us, has not previously formed and published in any other University in India or any other country or examining body to the best of our knowledge.

Place: Shivnagar

Date: 29/02/2020

Name of project students.

1. Lad Divya Dilip.
2. Patil Ashlesha Arun
3. Mohini Harale Rajendra.
4. Damame Aniket Anil.

CERTIFICATE

This is to certify that thesis entitled **"Synthesis, Characterization of WO_3 thin film by sol-gel route for electrochromic smart windows application"** which is being submitted herewith is the result of original research work completed by **Miss. Lad Divya Dilip, Miss. Patil Arun Ashlesha, Miss. Mohini Harale Rajendra, Mr. Damame Aniket Anil** under my supervision and guidance and to the best of my knowledge and belief, the work embodied in this project work has not formed earlier.

Place: Shivnagar

Date: 29/02/2020

Project Advisor

(Dr. Dhanaji S. Dalavi)

1. Introduction:

The term chromogenic is referred to as the change in optical properties of the compound when it is subjected to change in their environment. So, depending upon the chosen environment chromogenic devices are divided into thermochromic device, photochromic device, electrochromic device, phase dispersed liquid crystal device, gasochromic device and suspended particle liquid crystal device. The history of electrochromism started in 1704, when Diesbach discovered the Prussian blue, an excellent dye which had also electrochromic properties. This material changes its color from dark blue to transparent when a voltage is applied across it. In 1815 the electrochromism of WO_3 was discovered, by Berzelius [1]. In fact, it was showed that pure WO_3 changed color on reduction when warmed under a flow of dry hydrogen gas. Later in 1824 Wohler effected a similar chemical reduction with sodium metal. Kobosew and Nekrasso in 1830, recorded that WO_3 powders could acquire the color blue by electrochemical reduction in an acidic solution. The first step towards an electrochromic device was taken in 1942 by Talmey, in studies on the coloration associated with electrolytic reduction of artificially produced particulate molybdenum and tungsten oxide layers. In 1953 Kraus made a very clear description of electrochromism in tungsten oxide films. As none of these studies attracted much attention, probably most current investigators attribute the first widely accepted suggestion of an electrochromic device to Deb, in 1969, with the tungsten oxide films, and after this point, there was a visible increase of the interest in electrochromism. In spite of the innovation on Deb's first electrochromic device it wasn't able to keep up with the fast development of liquid crystal devices [1, 2].

In 1971, Blanc and Staebler produced an electrochromic effect superior to most of the previously published. They applied electrodes to the opposing faces of doped, crystalline SrTiO3 (Strontium Titanium Trioxide) and observed an electrochromic color move into the crystal from the two electrodes. In 1972, Beegle developed a display having identical counter and working electrodes as the one from Blanc and Staebler, but made of WO_3 [1, 2]. Nowadays, Deb's paper form 1973 is quoted as the work responsible for the true birth of electrochromic technology. Faughan et al. [3] in 1975 accomplished a significant progress in developing the electrochromic display device. This was followed by an increase in electrochromic devices developed for display applications. Nevertheless, electrochromism has remained an active area for basic and applied research, with large possibilities for applications in emerging technologies.

The interest was boosted in the mid-1980s with the awareness that electrochromism was of much interest as a mean to achieve energy efficiency in buildings, using smart windows [4]. The smart windows and other electrochromic systems consist of two electrodes and an electrolyte. When applied voltage with appropriate polarity, charge in the cell drives in and out of the electrochromic material and an electrochemical redox reaction causes a corresponding color change. Therefore, electrochromic materials are currently attracting much interest in industry for their commercial applications [5]. In the recent year various attempts has been made to prepare nanostructured electrochromic devices with the help of various sophisticated physical and chemical techniques and tools. Physical techniques require sophisticated instruments which are of high cost which impact on the end product to be delivered in the market. Sol-gel route is the simple and inexpensive technique which is capable to produce highly transparent nanostructured WO_3 thin film.

Therefore, in the present project an emphasis has been given to synthesize WO3 thin films by simple, low cost sol-gel dip coating technique.

2. Synthesis of Nanostructured WO_3 thin film:

The precursor solution used for the deposition of WO_3 thin films was prepared by dissolving 7.48 g of tungsten metal powder (99% pure, Sigma Aldrich) in 80 ml of H_2O_2 (30%) [6]. The reaction mixture that was kept for 48 h with constant stirring yielded a deep yellow-coloured PTA sol. As reaction being exothermic, it was conducted between 0 and 10^{o}C in an ice bath. After completion of reaction the reaction mixture was filtered with whatman filter paper and heated at 55 ^{o}C in order to remove excess peroxide. As-prepared sol was used as a starting precursor for the deposition of WO_3 thin films and kept for to form gel. The WO_3 thin film of desired thickness was deposited by using sol-gel dip coating method.

3. Characterization:

The structural properties of the films were studied by X-ray diffraction (XRD) patterns recorded using X-ray diffractometer (Bruker AXS Analytical Instruments Pvt. Ltd., Germany), D2 phaser model with Cu-Ka radiation (k = 1.5418 A°). The scanning rate of 10^{o}/min was applied to record the patterns in the range of 10^{o} -80^{o}. The infrared (IR) spectrum of powder collected from all NiO samples were recorded using Perkin–Elmer IR spectrophotometer (model-100) in the spectral range of 400–4,000 cm^{-1}. The pellets were prepared by mixing KBr with WO_3 powder collected by scratching film from glass substrates, in the ratio 300:1 and then pressing the powder between two pieces of polished steel. The surface morphology of the films was examined by scanning electron microscopy (SEM; Model JEOL-JSM-6360, Japan, operated at 20 kV) with a thin layer of gold sputter coated prior to analyses. The optical transmittance spectra of fully colored and fully bleached states were measured over the range of 350–1,100 nm using an UV-vis spectrophotometer (Shimadzu, model: UV-1800, Japan). All the electrochromic measurements were performed in an electrolyte (1 M $LiClO_4$+Propylene carbonate) in a conventional three-electrode arrangement comprising platinum wire as the counter electrode and SCE serving as the reference electrode using electrochemical quartz crystal measurements (model-CHI-400A) made by CH Instruments, USA. Colorimetric determinations were done with the help of Shimadzu color analysis software by analyzing the transmittance spectra of color/bleach state to evaluate the L*a*b* and Yxy coordinate values. These obtained values were used as reference data in order to get the observed color in reduced and oxidized state for all samples from online color analysis software with 1931 2° observer and D-65 illuminant proposed by CIE Yxy and L*a*b* coordinate.

4. Results and Discussion:

4.1 X-Ray Diffraction:

The X-ray diffraction (XRD) pattern of nanostructured WO_3 thin film deposited on ITO/glass substrate is shown in Fig.1. It was observed that, the XRD exhibits a broad hump in the low 2θ region for nanostructured WO_3 thin film typically of an amorphous in nature. Normally, amorphous WO_3 film is more suitable than crystalline WO_3 film for electrochromic applications. A crystallized structure is less favorable for ions to diffuse through because of the densely packed atomic structure and due to this lithium ion movement through the film is obstructed by the dense structure leading to a lower response time. X-ray diffraction patterns realized on these film allowed to confirmed that WO_3 film is totally amorphous. Such characteristics, typical of amorphous materials combined with a nanostructured WO_3, are favorable for a fast-electrochromic response.

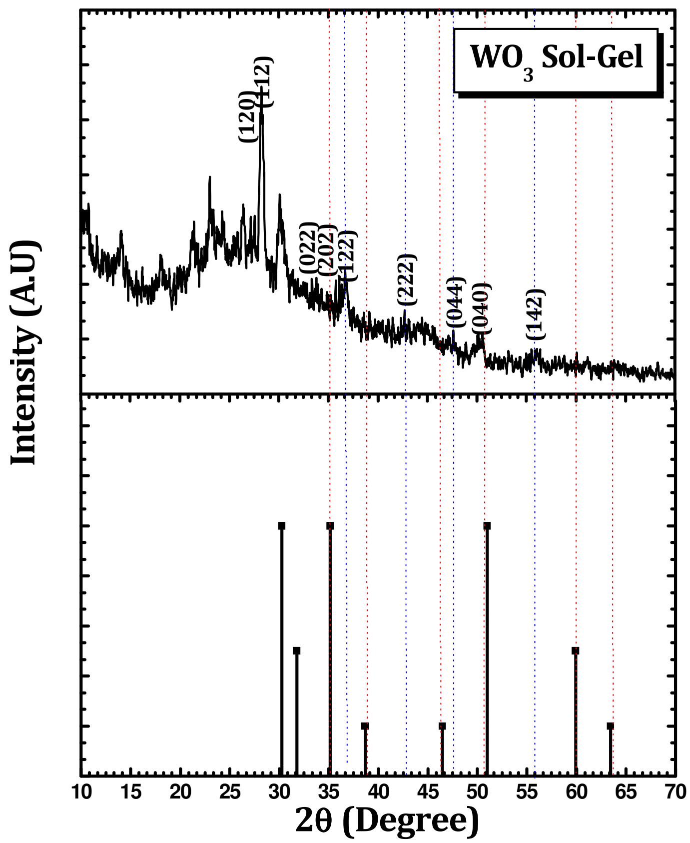

Figure.1 X-ray diffraction pattern of sol-gel deposited WO_3 thin film

4.2 FT-IR Analysis:

Fig 2. Shows FT-IR spectra of sol gel deposited nanostructured WO_3 thin film. A single absorption band observed at 950 cm^{-1} is characteristic for the terminal W=O stretching vibration in tungsten trioxide [7].

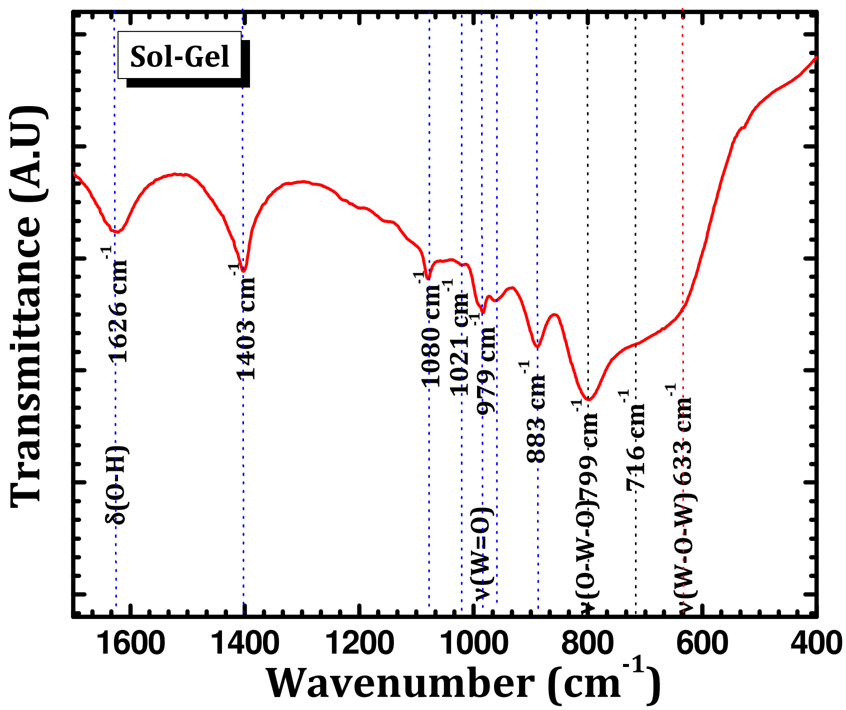

Figure.2 FT-IR spectrum of sol-gel deposited WO_3 thin film.

A well-defined bands seen at 799 and 883 cm^{-1}, in the spectra of nanostructured WO_3 thin film is due to the (O–W–O) inter bridging stretching mode in WO_3 [8]. However, the band at 633 cm^{-1} is due to W–O–W stretching vibrations. A band centered at 1626 cm^{-1} ascribable to the δ(H–O–H) deformation mode is also observed in spectrum of the NPs-WO_3 thin film and a band due to the W–OH…OH_2 stretching mode of hydroxyl groups linked to tungsten on one side and hydrogen bonded with water molecules, on the other, is produced at 1403 cm^{-1}[9].

4.3 Morphological Study:

Fig. 3 (a and b) shows low- and high-resolution SEM images of nanostructured WO_3 thin film. Fig. 3 (a and b) revealed agglomerated nanoclusters with average nanoparticles size of 30-40 nm. The film is uniform in nature with high surface are which is beneficial for good electrochromic performance. The thickness of the deposited film is observed to be ~950 nm as depicted in Fig. 3(c). The existence of tungsten and oxygen in the prepared film was confirmed by the EDS results as shown in Fig 3 (d). It is noted that the high oxygen content in the results was due to the influence of the ITO glass substrate, which was also confirmed by the existence of In and Sn in the EDS analysis.

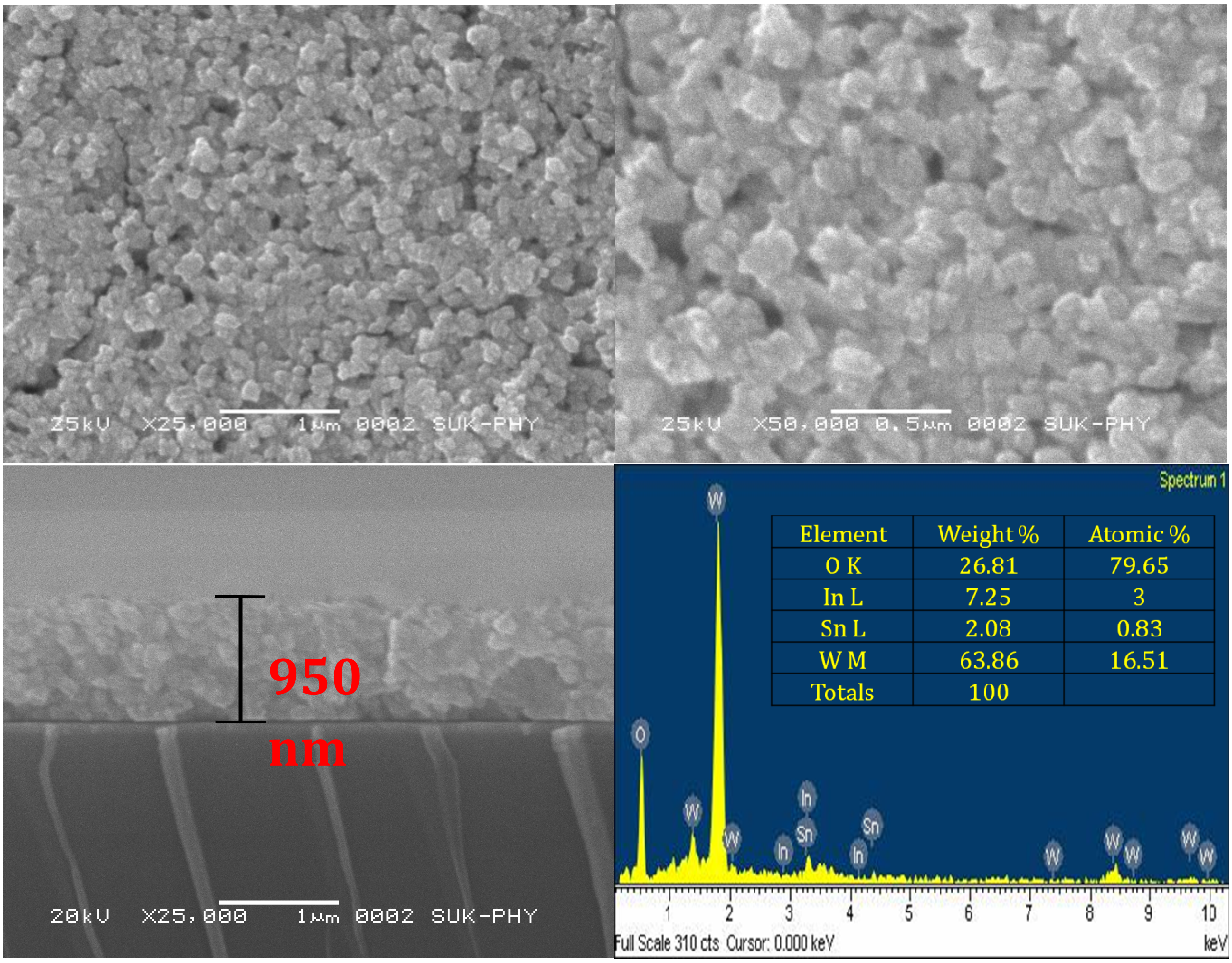

Figure.3 (a and) shows low- and high-resolution images (c) cross sectional image of and (d) EDS spectrum of nanostructured WO_3 thin film deposited on ITO coated conducting glass substrate.

4.4 Electrochromic Study:

Cyclic voltammetry (CV) technique is employed to investigate the cathodic/anodic behavior of WO_3 thin film. The CV was recorded at different scan rates carrying from 20 mV/Sec to 100 mV/sec in 1 M $LiClO_4$-PC electrolyte with a potential window of +1.4 to -1.4 V. The shape of the curves is typical of electrochromism in nanostructured WO_3 film. It is observed that the cathodic and anodic current densities for the nanostructured WO_3 film was 4.5 mA/cm^2 (cathodic) and 2.5 mA/cm^2 (anodic) at the scan rate of 20 mV/Sec and achieved a value as high as 6 mA/cm^2 (cathodic) and 3.9 mA/cm^2 (anodic) at 100 mV/Sec. The progressive increase in the cathodic and anodic current densities with respect to scan rate indicates the reduction of the W^{6+} ionic state to the W^{5+} state due to intercalation of Li^+ ions towards extreme cathodic potentials as a result of {$WO_3 + Li^+ + e^- \rightarrow Li_xWO_3$} reaction and eventually responsible for blue coloration. Upon anodic polarization (+1.4V), oxidation of WO_3 takes place with simultaneous deintercalation of Li^+ ions and e^- from the film to acquire a transparent (bleached) state as a result of {$Li_xWO_3 \rightarrow WO_3 + Li^+ + e^-$} reaction. When the potentials swept from -1.4 V to +1.4 V the reduced W (i.e: W^{5+}) gets converted into W^{6+} state. It is well known that the area under the curve is directly related to the amount of charge intercalated in the film. This confirms that the nanostructured WO_3 thin film shows pronounced electrochromic properties.

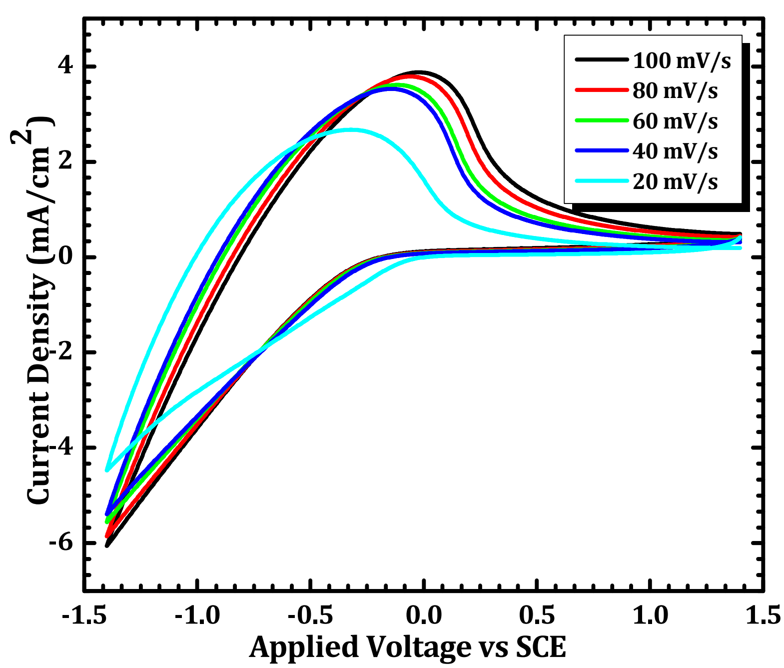

Figure.4 Cyclic voltammograms for the coloration and bleaching cycles of the nanostructured WO_3 thin film recorded in 1M $LiClO_4$-PC electrolyte at different scan rates with a potential window from +1.4 to -1.4V versus SCE.

4.5 X-Ray Photoelectron Spectroscopy Analysis:

X-ray photoelectron spectroscopic (XPS) analysis was carried out on the nanostructured WO_3 thin film to investigate the generation of reduced and oxidized tungsten species under the influence of cathodic and anodic potentials. The binding energies of the samples were corrected using a value of 284.6eV for the C 1s peak of carbon. There is no other contaminated element except C in the nanostructured WO_3 film. Fig. 5 (a) shows the XPS spectra of nanostructured WO_3 film under the action of anodic (+1.4 V) potential.

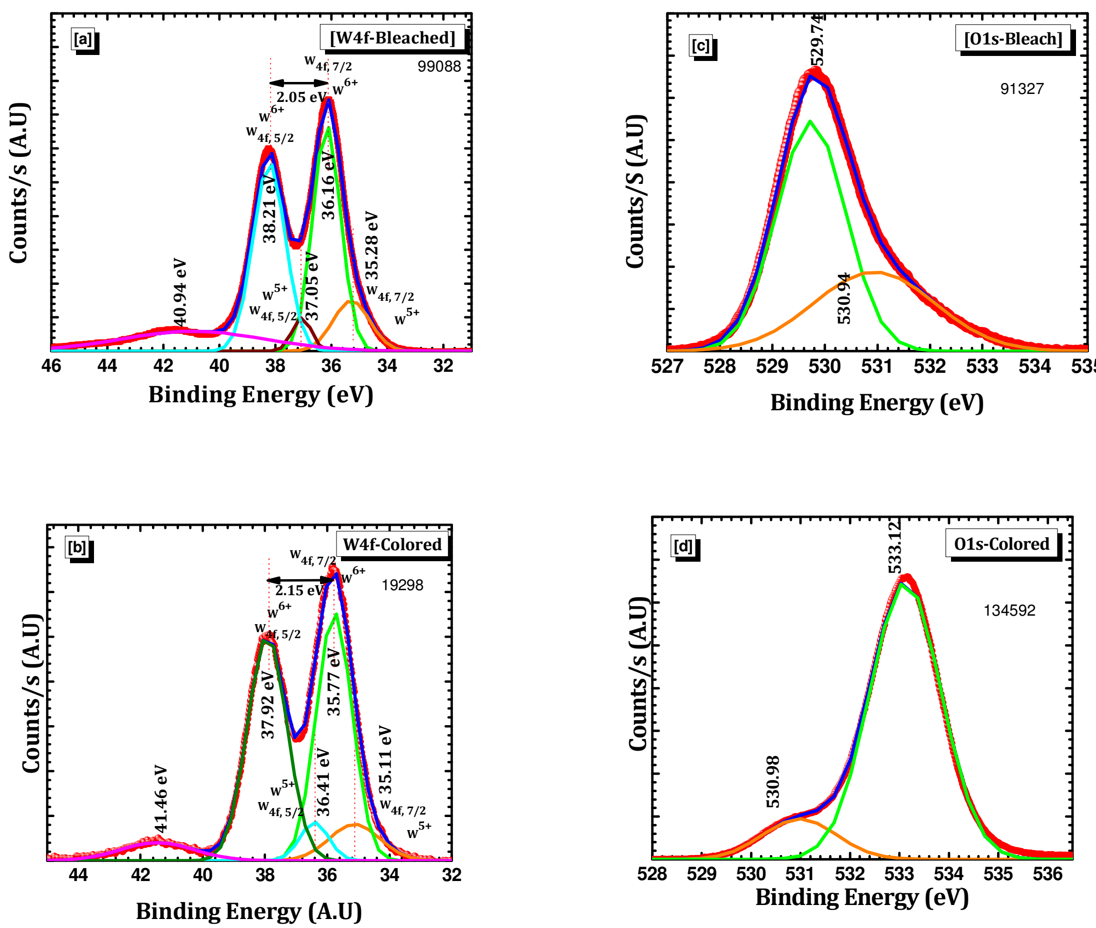

Figure 5. High resolution XPS spectra (a and b) of the W (4f) and (c and d) O (1s) core levels of the WO_3 thin film in bleached and colored state, respectively.

The analysis using XPS revealed a tungsten 4f spectrum in the bleached state composed of the $W4f_{5/2}$ and $W4f_{7/2}$ peaks, which may be deconvoluted into Gaussian peaks centered at

38.21 and 36.11 eV, with XPS $W4f_{7/2}$–$W4f_{5/2}$ spin-orbit separation being 2.05 eV and the area ratio of the two peaks of each doublet being 0.96 corresponds to the tungsten in W^{6+} valence state, which suggests that the film have nominal stoichiometry [10]. On the other hand, the other doublet at 35.28 and 37.05 eV corresponds to a typical W^{5+} oxidation state of W. However, during cathodic (-1.4 V) potential (colored state) peaks corresponds to $W4f_{7/2}$ and $W4f_{5/2}$ shifts toward lower binding energies located at 35.77 eV, 35.11 eV and 37.92 eV, 36.41 eV respectively (Fig.5 (b)). This indicates that the redox reaction takes place between W^{6+} and W^{5+}. The XPS O1s spectrum in both bleached and colored state has been deconvoluted into two components (Fig.5 (c, d)). The binding energy of the first component situated at 529.74 eV (before coloration) above the W $4f_{7/2}$ core level line, corresponds to the W=O bond in the oxide (Fig.5 (c)). However, there is increase in the intensity and shift in binding energy towards higher energy (533.12 eV) after coloration. The second component in both bleached and colored state observed at about 530.94 eV and 530.98 eV could be assigned to water bounded in the film structure or to water molecules adsorbed on the sample surface [11].

4.6 Reversibility:

Chronocoulometry gives quantitative information about the number of protons/ions intercalated or deintercalated on the application of a potential double step for a known amount of time. The reversibility is then given by the ratio of charges deintercalated to the charges intercalated,

i.e.

$$\text{Reversibility} = \frac{Q_{di}}{Q_i}$$

From the chronocoulometry studies (Fig. 6), the electrochromic reversibility of nanostructured WO_3 film was found to be 75 %.

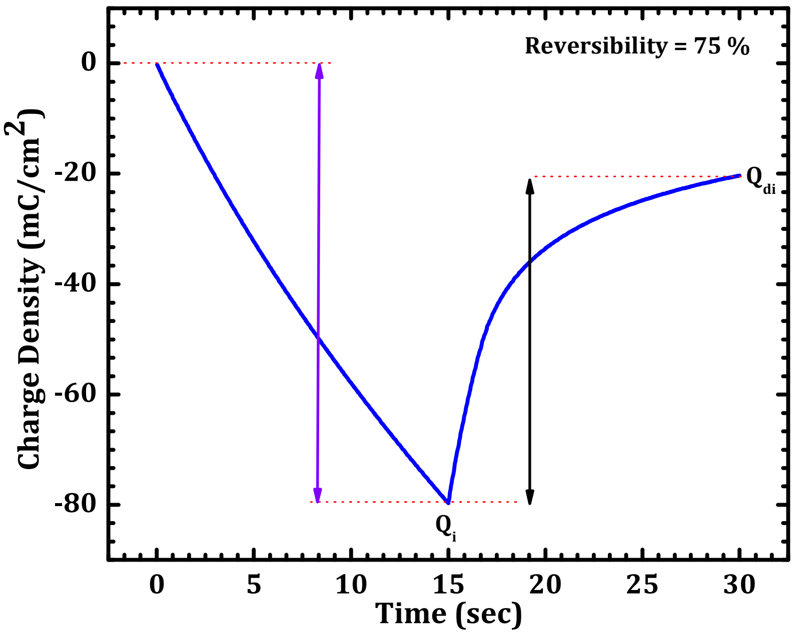

Figure. 6 Chronocoulometry curves of a nanostructured WO_3 thin films recorded in recorded in 1M $LiClO_4$-PC electrolyte upon application of step potential of −1 to +1.4 V vs SCE.

4.7 Optical Transmittance Study:

Fig.7 (a) shows the optical transmission spectra of WO_3 thin film at different applied potentials of -0.2, -0.6, -1.0 and -1.4 V respectively, in the wavelength range from 300 to 1100 nm. The optical transmittance of nanostructured WO_3 thin film in the bleached state (+1.4 V) was found to be 67 % at 555 nm and it changes immensely to 3 % as the potential switched to -1.4 V. Therefore, the optical transmittance modulation of nanostructured WO_3 thin film was 64 %. The enhancement in the transmittance modulation of nanostructured WO_3 thin film because of large surface area and increased textural boundaries where actual coloration/bleaching processes take place. The coloration efficiency (g) describes the optical density change (ΔOD) at a specific wavelength as a function of the injected/ejected electronic charge (Qi), i.e., the amount of charge required to change the optical density, as shown in Eq. 2 [12].

$$\eta = \left(\frac{\Delta OD}{Q_i}\right)_{\lambda=550\ nm} = \left(\frac{\ln(T_b/T_c)}{Q_i}\right), \qquad (2)$$

where T_b is the bleached transmittance and T_c is the colored transmittance. The coloration efficiency of the nanostructured WO_3 thin films has been shown in the Table.1. The high coloration efficiency supports from the fact that nanostructured WO_3 with smaller dimensions prepared by sol-gel provide larger surface area for charge-transfer reactions. It makes the diffusion of ions easier among the materials.

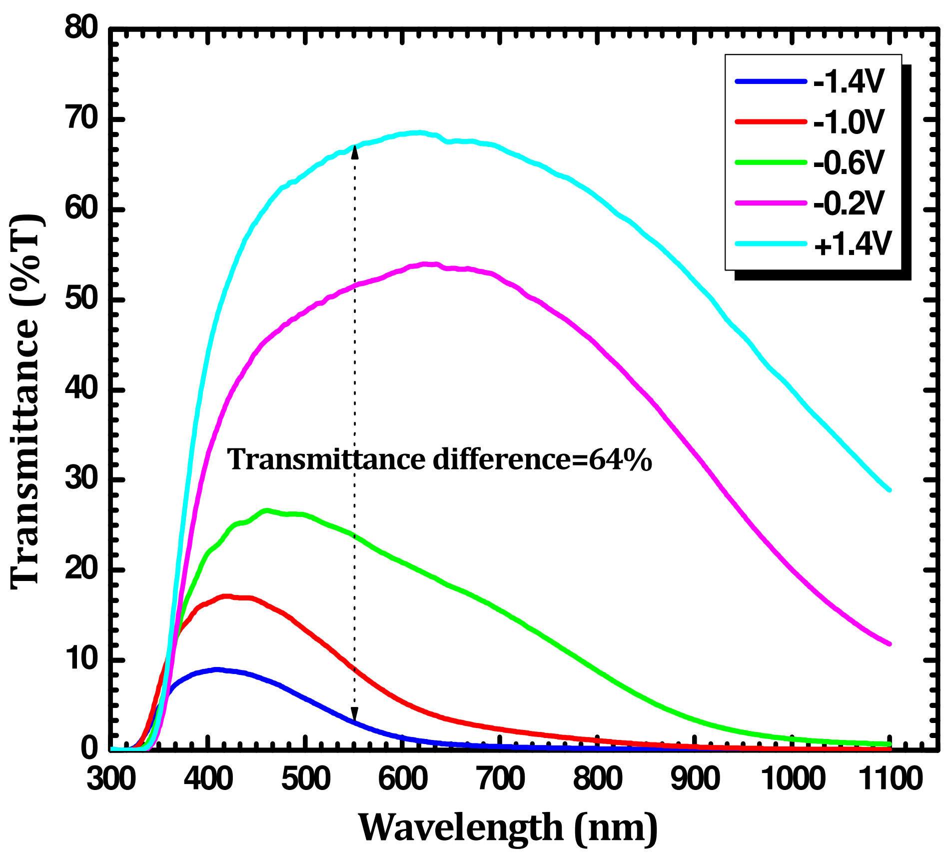

Figure 7. Optical transmission spectra showing colored and bleached states of WO_3 thin film with respect to applied potential.

Table.1 shows various preparative parameters evaluated from electrochromic and optical transmittance studies.

Applied Voltage	Photopic Transmittance T (%)		Photopic Transmittance difference $\Delta T_{Photopic}$ (%)	Optical Density $(\Delta OD)_{\lambda=555\ nm}$	Coloration efficiency (cm^2/C) λ=555 nm
	(T_P) bleached	(T_P) colored			
-0.2	67	51.5	15.5	0.2631	
-0.6	67	24	43	1.02	116
-1.0	67	9	58	2.007	
-1.4	67	3	64	3.10	

4.8 Chromaticity Analysis:

A two-dimensional x-y representation known as the chromaticity diagram utilized to identify the colors of WO_3 thin film in its oxidized and reduced state as shown in Fig.8 (a-b). The shift in x-y co-ordinates occurs once the potential switched from oxidized to reduced state. Fig.4 (a) shows the CIE chromaticity curve of nanostructured WO_3 thin film at different applied potentials. Initially when nanostructured WO_3 thin film is in oxidized state, exhibits a transparent state and its position on the chromaticity curve is close to the white point. As cathodic potential increased from +1.4 to -1.4 V, color of the film immensely changes from transparent to dark blue state as seen by the shift in the position of the x-y coordinate on the chromaticity diagram. In the CIE 1931 Yxy color space, the tristimulus value Y is defined as a measure of the brightness or luminance of the color [13, 14]. Fig.8 (b) shows the relative luminous transmittance (% Y) with applied potential for nanostructured WO_3 thin film. As the potential is switched from +1.4 V to -1.4 V vs SCE, a large change in the xy coordinates occurs as the relative luminance changes from 67 % (bleached) to 3 % (colored) having luminous transmittance difference (ΔY) of 64 %.

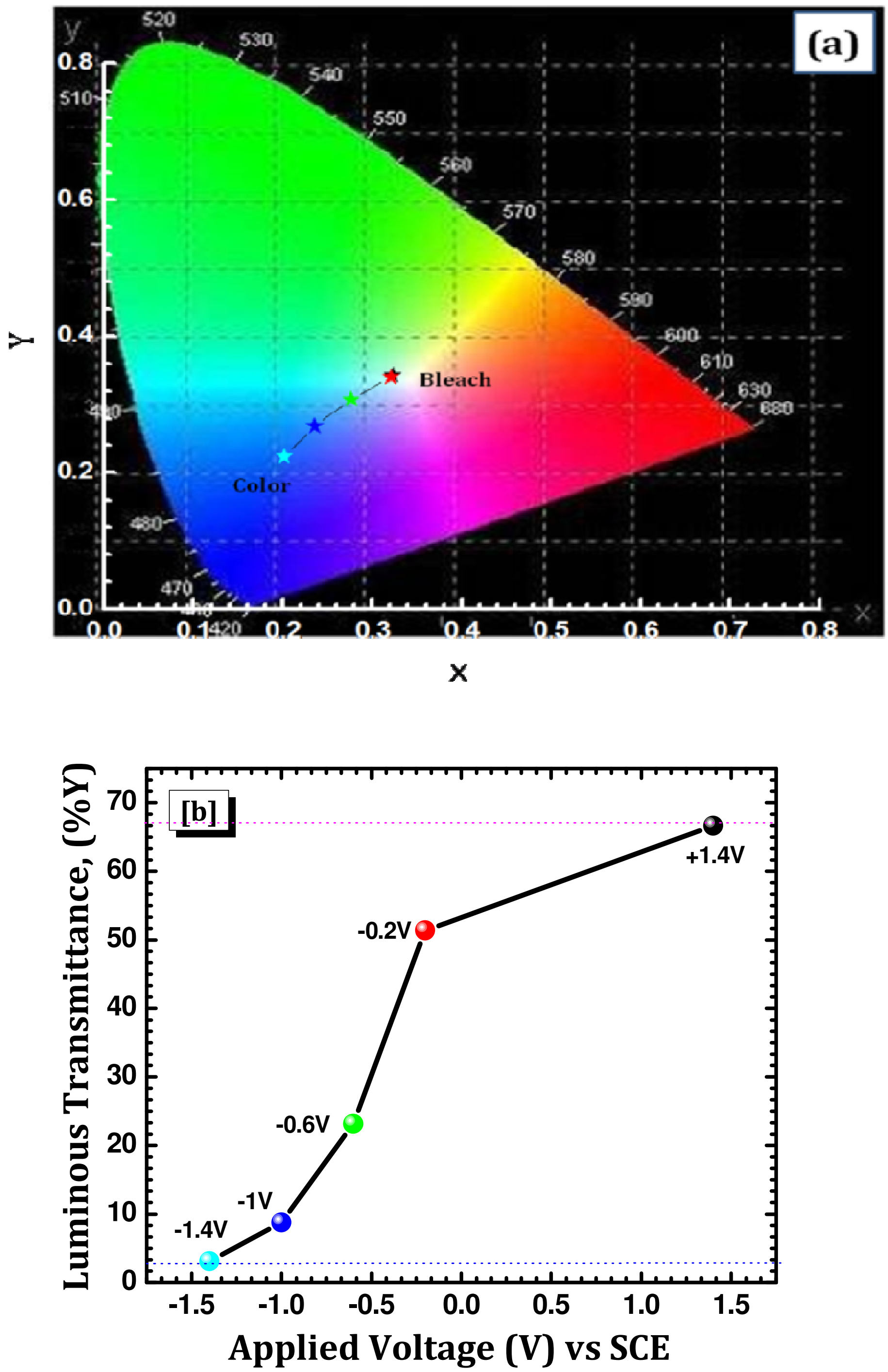

Figure 8. (a) CIE 1931Yxy chromaticity diagram and (a) Luminous transmittance for WO_3 thin film at different applied voltage. The dotted horizontal lines (Fig.8 (b)) indicate difference of luminous transmittance in its colored and bleached state.

Conclusions:

Nanostructured WO_3 thin film has been deposited by sol-gel dip coating method for energy efficient electrochromic smart window application. The XRD pattern confirms the formation of nanocrystalline WO3 thin film with amorphous background which is suitable for electrochromic window application. A well-defined bands observed at 799 and 883 cm^{-1}, in the FT-IR spectra of nanostructured WO_3 thin film is due to the (O–W–O) inter bridging stretching mode in WO_3 confirms the formation of WO_3. From electrochromic study it has been concluded that the sol-gel deposited nanostructured WO_3 thin films exhibits transmittance modulation of 64 % at 555 nm, reversibility of 75 % and coloration efficiency of about 116 cm^2/C. The good transmittance modulation and excellent coloration efficiency of the WO_3 thin films is due to large surface area provided by nanostructured WO_3 thin film. From CIE system of colorimetric analysis and Luminous transmittance modulation it has been evidenced that the color of the WO_3 thin immensely changes from transparent to deep blue which confirms that the film deposited by sol-gel route are well suited for energy efficient electrochromic smart window application.

Acknowledgement:

Project advisor Dalavi and students are thankful to Shivaji University Kolhapur to sanction research proposal through Research Promotion activity for students of affiliated college. We are also thankful to Principal, S.G.M College, Karad for the release of grant.10,000/- and organized Research workshop for our college student to upgrade knowledge in the field of research. We also thankful to our Principal, Dr. C. B. Salunkhe and Co-ordinator, Mr. N. V. Gaikwad, Krishna Mahavidyalaya, Rethare (Bk), for successful implementation of the project.

References:

1. P. M. S. Monk, R. J. Mortimer, D. R. Rosseinsk, Cambridge University Press. (2007).
2. C. G. Granqvist, Handbook of inorganic Electrochromic Materials, Elsevier. 2002, 106.
3. B. W. Faughnan, R. S. Crandall, P. M. Heyman, RCA Rev. 1975, 36 177.
4. E. Avendano, L. Berggren, G. A. Niklasson, C. G. Granqvist, A. Azens, Thin Solid Films. 2006, 496 30.
5. Y. Takahashi, N. Hayashi, K. Oyaizu, K. Honda, H. Nishide, Polymer Journal, 2008, 40 763.
6. D. S. Dalavi, R. S. Devan, R. A Patil, R. S. Patil, Y. R. Ma, S. B. Sadale, I. Y. Kim, J. H. Kim, P. S. Patil J Phys Chem C 1: 2013, 3722–3728.
7. A-C. Dippel, T. Schneller, W. Lehmann, B. Reichenberg and R. Waser, J. Mater. Chem, 2008, **18,** 3501
8. M. Deepa, P. Singh, S. N. Sharma and S. A. Agnihotry, Sol. Energy Mater. Sol. Cells, 2006, **90,** 2665
9. B. Orel, N. Groselj, U. Krasovec, R. Jese, A. Georg, J. Sol-Gel Sci. Technol. 2002, **24,** 5.
10. Y.F. Lu, H. Qiu: J. Appl. Phys, 2000, **88,** 1082.
11. J. Zhang, J. P. Tu, X. H. Xia, Y. Qiao and Y. Lu, Sol. Energy Mater. Sol. Cells, 2009, 93, 1840.
12. J.S.E.M. Svensson and C.G. Granqvist, Proc. SPIE Vol, 1984, **502,** 30.
13. V. Wittwer, O. F. Schirmer, P. Schlotter, Disorder, Solid State Commun, 1978, **25,** 977.
14. D. S. Dalavi, R. S. Devan, R. S. Patil, Y-R. Ma, P. S. Patil, Mat. Letters, 2013, **90,** 60.