

Shetkari Shikshan Prasarak Mandal's

Krishna Mahavidyalaya, Rethare Bk

IQAC 2018-2019

ACTIVITY REPORT  
PHYSICS DEPARTMENT

IQAC ACTIVITY No:

NAME OF THE ACTIVITY: "Lead college Activity-Research Project: "Application of nanostructured PANI film for electrochromic smart window and supercapacitor 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
10.00 am-11.00 am	Physics laboratory	04 students+01 teacher	Indoor
SUPPORT/ASSISTANCE:	Nil		

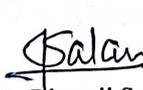
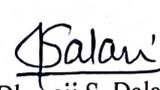
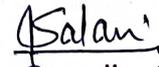
BRIEF INFORMATION ABOUT THE ACTIVITY (CRITERION NO. - ):

TOPIC/SUBJECT OF THE ACTIVITY	"Lead college Activity-Research Project: "Application of nanostructured PANI film for electrochromic smart window and supercapacitor 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 <b>HEAD</b>	 Principal	 <b>IQAC, Coordinator,</b> KRISHNA MAHAVIDYALAYA, Rethare Bk; Shivnagar - 415108 Tal. Karad, Dist. Satara

DEPARTMENT OF PHYSICS  
KRISHNA MAHAVIDYALAYA, Rethare Bk,  
Rethare Bk; Shivnagar - 415108 Tal. Karad - 415 108 (MS)



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 : Dr. Salunkhe C. B., M.Sc., Ph.D.

Founder : Hon. Jaywantrao Bhosale



Ref. No. : KMR/

Date : 08/09/2018

To,  
The Co-coordinator  
Lead College Activity  
SGM College, Karad

Subject: Submission of application for financial support to research project

Reference: SU/Post graduate admission/6780 dated 5<sup>th</sup> July, 2018

Respected Sir,

With reference to the above mentioned subject, herewith I am forwarding project proposal entitled "**Fabrication of nanostructured Polyaniline thin film for electrochromic smart windows and supercapacitor application**" under research sensitization scheme for college students initiated by Shivaji University, Kolhapur from June 2017.

Herewith I kindly request you to consider the said project proposal for possible selection.

  
Yours' Faithfully  
PRINCIPAL (I/C)  
KRISHNA MAHAVIDYALAYA  
RETHARE (BK.), TAL. KARAD

Received  
V.B. Singh  
11/8/2018

: Founder :

Estd.: 1954



Padmabhushan  
Karmaveer Bhaurao Patil  
D.Lit.



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

Rayat Shikshan Sanstha's

## Sadguru Gadage Maharaj College, Karad

NAAC ACCREDITED : A<sup>+</sup> CGPA 3.63

(Junior & Senior)

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**

■ Jr. College No. J.21.02.003 ■ (Affiliated to Shivaji University, Kolhapur) ■

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

Ref. No. 1517/2018-19

Date :

27/10/2018

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) Desavale Suryashree Vilasrao	Fabrication of Nanostructured Polyaniline thin film for electrochromic smart windows and supercapacitor application.	10,000/-
	2) Jadhav Amol Vijay		
	3) Harale Mohini Rajendra		
	4) Jadhav Nikita Bharat		

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

Thank you,

Yours faithfully,

Principal,

Sadguru Gadage Maharaj College,  
KARAD



a/c

स्थापना : १९५४

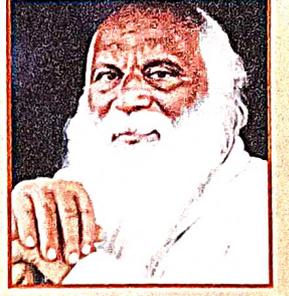


“स्वावलंबी शिक्षण हेच आमचे ब्रीद”-कर्मवीर  
रयत शिक्षण संस्थेचे,

# सद्गुरु गाडगे महाराज कॉलेज, कराड

विद्यानगर, कराड पिन - ४१५ १२४ जि. सातारा (महाराष्ट्र) पो. ऑ. बॉ. नं. ३  
फोन : कार्यालय : (०२१६४) २७१३४६ निवास : (०२१६४) २७१७९४ फॅक्स : (०२१६४) २७१३४६  
Website : www.sgm.edu.in E-mail : sgmkarad@yahoo.com

• संस्थापक •



पद्मभूषण डॉ. कर्मवीर भाऊराव पाटील  
डी.लिट्.

नॅक मानांकन : A<sup>+</sup> CGPA 3.63

• प्राचार्य,  
डॉ. मोहन राजमाने  
एम.एस्सी., पीएच्.डी.

**कला, विज्ञान, वाणिज्य व व्यवसाय शिक्षण**

**(कनिष्ठ व वरिष्ठ)**

**(शिवाजी विद्यापीठ, कोल्हापूर संलग्नित)**

संदर्भ क्र. : १९९४/१९-१९

दिनांक :

०८/०९/२०१९

## REGISTERED AD

प्रति,

मा.प्राचार्य,  
कृष्णा महाविद्यालय, रेठरे बु ११  
जि.सातारा

विषय : अग्रणी महाविद्यालय योजनेअंतर्गत रिसर्च प्रोजेक्टसाठी घावयाच्या  
अॅडव्हान्साबाबत.

संदर्भ : आपलेकडील जा.क्र. केएमआर दि.०८/०९/२०१९ चे पत्र.

महोदय,

आपलेकडील वरील संदर्भपत्रास अनुसरून कळवू इच्छितो की, शिवाजी विद्यापीठाच्या  
Research Promotion Activity for students of the affiliated Colleges या योजनेअंतर्गत आपल्या  
विद्यार्थ्यांच्या "Fabrication of Nanostructured Polyaniline thin film for electrochromic smart  
windows and supercapacitor application" या रिसर्च प्रोजेक्टसाठी विद्यापीठाने रु. १००००/-  
मंजूर केले असून सदर रिसर्च प्रोजेक्टसाठी सोबत रु.८०००/- चा अॅडव्हान्स रकमेचा चेक नं. ७३४३०  
दि. १०/०९/२०१९ ने सोबत पाठविला आहे. कृपया सदर रकमेची पोहोच पावती त्वरीत पाठवून  
घावी.

वरील रिसर्च प्रोजेक्टसाठी मंजूर रक्कम रु. १०,०००/- खर्च करून त्याचा हिशोब व प्रोजेक्ट  
रिपोर्ट या अग्रणी महाविद्यालयाकडे त्वरीत सादर करावा म्हणजे उर्वरीत रक्कम अदा करणे सोईचे  
होईल.

कळावे, ही विनंती.

  
समन्वयक,

अग्रणी महाविद्यालय,  
स.गा.म.कॉलेज, कराड



  
Load college  
chef  
आपला विश्वासू,  
प्राचार्य,  
अग्रणी महाविद्यालय  
सद्गुरु गाडगे महाराज कॉलेज, कराड

सोबत : वरीलप्रमाणे.



संहती कार्यसाधिका । शिलं परं भूषणम्  
Shetkari Shikshan Prasarak Mandal's  
**KRISHNA MAHAVIDYALAYA, RETHARE BK.**

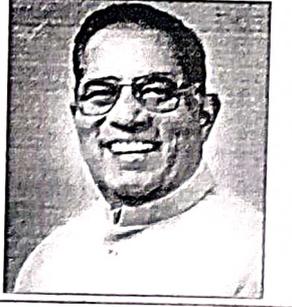
Shivnagar, Tal. Karad, Dist. Satara, 415108 (M.S.)

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NAAC 'B+' Grade (CGPA 2.65)

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

Founder : Hon. Jaywantrao Bhosale



Ref. No. : KMR/

Date :

प्रति.

मा . समन्वयक

अग्रणी महाविद्यालय

सदगुरु 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 "Fabrication of Nanostructured Polyaniline thin films for electrochromic window and supercapacitor application" या रिसर्च प्रोपोसलं साठी विद्यापीठाने रु. १००००/- मंजूर केले होते. सदर रिसर्च प्रोपोसलं साठी आपणाकडून रु. ८०००/- चा ऍडव्हान्स रकमेचा चेक नं. ७३४३० दि. १०/०१/२०१९ रोजी मिळाला असून त्यानुसार वरील रिसर्च प्रोजेक्टसाठी मंजूर रकमेच्या खर्चाचा तपशील व अहवाल आपणाकडे पाठवीत आहे.

तरी उर्वरित रु.२०३२/- या महाविद्यालयास पाठविण्यात यावेत हि नम्र विनंती

खर्चाचा तपशील खालीलप्रमाणे .

अ.नं	तपशील	साहित्य	खर्च
१	Shri. Samarth Trading Company	Chemicals	6620.00
२	Shri. Samarth Trading Company	Glasswares	2026.00
३	Anushka Stationary and General Stores	Stationary	1216.00
	Uma Stores and Xerox	Glass Cutter	120.00
४	Agrani Workshop, SGM college, Karad	Students and Advisor Travelling	150.00
५		Total	10,032=00

समन्वयक

अग्रणी महाविद्यालय विभाग

कृष्णा महाविद्यालय, करार नगर, ता. करार (सातारा)

Dr. C. B. Salunkhe  
PRINCIPAL  
KRISHNA MAHAVIDYALAYA  
RETHARE (BK.), TAL. KARAD



# Shri Samarth Trading Company

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



Original Buyer's Copy

Invoice No: CO/0345/2018-19 ( Physlcs Dept. )

Invoice date: 22 / 02 / 2019

Reverse Charge (Y/N):

State: Maharashtra

PO No.

Date :

Code 27

Transport Mode:

Vehicle number:

Date of Supply :

Challan No.

Bill to Party

Ship to Party

Name: The Princpal, Krishna Mahavidyalaya,

Address : Shlvnagar

Dist : Satara

GSTIN:

State: Maharashtra

Name:

Address:

GSTIN:

State:

Code 27

Code

S. No.	Product Description	HSN code	GST	Qty	Rate	Amount	Discount	Taxable Value	CGST		SGST		Total
									Rate	Amount	Rate	Amount	
1	Ferric Chloride Hexa. 500 gm.		18%	1	270.00	270.00	108.00	162.00	9	14.58	9	14.58	191.16
2	Potassum Ferrcyanide 500 gm.		18%	1	1500.00	1500.00	600.00	900.00	9	81.00	9	81.00	1062.00
3	Polyvhyal Alcohol 500 gm.		18%	1	560.00	560.00	224.00	336.00	9	30.24	9	30.24	396.48
4	Ammonia (25-30%) 2.5 Lit.		18%	1	580.00	580.00	232.00	348.00	9	31.32	9	31.32	410.64
5	Hydrogen Peroxide (35%) 500 ml.		18%	2	350.00	700.00	280.00	420.00	9	37.80	9	37.80	495.60
6	Sodium Dodecyl sulphate 500 gm.		18%	1	560.00	560.00	224.00	336.00	9	30.24	9	30.24	396.48
7	Absolut Ethanol 500 ml.		18%	2	360.00	720.00	288.00	432.00	9	38.88	9	38.88	509.76
8	Polyethylenye Glycol 500 ml.		18%	1	400.00	400.00	160.00	240.00	9	21.60	9	21.60	283.20
9	Zinc Acetate 500 gm.		18%	1	530.00	530.00	212.00	318.00	9	28.62	9	28.62	375.24
10	Potassium Hydroxide 500 gm.		18%	1	330.00	330.00	132.00	198.00	9	17.82	9	17.82	233.64
11	Acetonitrile 500 ml.		18%	1	530.00	530.00	212.00	318.00	9	28.62	9	28.62	375.24
12	Hexamethylenetetramine (HMTA) 500 gm.		18%	1	300.00	300.00	120.00	180.00	9	16.20	9	16.20	212.40
13	Dietanolamine 500 ml.		18%	1	360.00	360.00	144.00	216.00	9	19.44	9	19.44	254.88
14	Potassium Persulphate 500 gm.		18%	1	470.00	470.00	188.00	282.00	9	25.38	9	25.38	332.76
15	Potassium Chloride 500 gm.		18%	1	190.00	190.00	76.00	114.00	9	10.26	9	10.26	134.52
16	Whatman Paper Pkt.No. (12.5cm)		18%	1	1350.00	1350.00	540.00	810.00	9	72.90	9	72.90	955.80
<b>Total</b>				18		9350.00	3740.00	5610.00		504.90		504.90	6619.80

Total Invoice amount in words

Six Thousand Six Hundred Twenty Rupees Only.

Bank Details

Bank A/C: 579505040000105 Bank Name : Union Bank of India  
Bank IFSC: UBIN0557951 Branch : Islampur

Declaration :

We declare that this invoice shows the actual price of the goods described and that all particulars are true and correct.

Company GSTIN/UIN : 27AMVPP2791E1ZG

Company PAN : AMVPP2791E



Total Amount before Tax

5610.00

Add: CGST

504.90

Add: SGST

504.90

Total Tax Amount

1009.80

Total Amount after Tax:

6619.80

Round Off Total Amount

6620.00

Certified that the particulars given above are true and correct

For SHRI SAMARTH TRADING COMPANY

*A. Tabaki*  
Authorised signatory

# 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

Invoice No: CO/0346/2018-19 ( Physics.Dept. )

Invoice date: 22/02 /2019

Reverse Charge (Y/N):

State: Maharashtra

PO No.

Date :

Code

27

Transport Mode:

Vehicle number:

Date of Supply :

Challan No.

Bill to Party

Ship to Party

Name: The Principal , Smt. K.R. P Kanya Mahavidyalaya

Address-Rethare BK.

Dist. Satara

GSTIN:

State: Maharashtra

Name:

Address:

GSTIN:

State:

Code

27

Code

S. No.	Product Description	HSN code	GST	Qty	Rate	Amount	Discount	Taxable Value	CGST		SGST		Total
									Rate	Amount	Rate	Amount	
1	Beaker 25 ml. Borosil		18%	2	99.00	198.00	59.40	138.60	9	12.47	9	12.47	163.55
2	Beaker 50 ml. Borosil		18%	2	68.00	136.00	40.80	95.20	9	8.57	9	8.57	112.34
3	Beaker 100ml. Borosil		18%	2	72.00	144.00	43.20	100.80	9	9.07	9	9.07	118.94
4	Beaker 250ml. Borosil		18%	2	75.00	150.00	45.00	105.00	9	9.45	9	9.45	123.90
5	Funnel 50mm. Borosil		18%	1	110.00	110.00	33.00	77.00	9	6.93	9	6.93	90.86
6	Pipette 5ml. Borosil		18%	2	160.00	320.00	96.00	224.00	9	20.16	9	20.16	264.32
7	Measuring Cylinder (small 25ml)		18%	1	315.00	315.00	94.50	220.50	9	19.85	9	19.85	260.19
8	Measuring Cylinder (small 50ml)		18%	1	340.00	340.00	102.00	238.00	9	21.42	9	21.42	280.84
9	Petri Dish 100 x 17 mm. Borosil		18%	2	245.00	490.00	147.00	343.00	9	30.87	9	30.87	404.74
10	Conical Flask 250ml. Borosil		18%	2	125.00	250.00	75.00	175.00	9	15.75	9	15.75	206.50
<b>Total</b>				17		2453.00	735.90	1717.10		154.54		154.54	2026.18

Total Invoice amount in words

Two Thousand Twenty-six Rupees Only.

Total Amount before Tax	1717.10
Add: CGST	154.54
Add: SGST	154.54
Total Tax Amount	309.08
Total Amount after Tax:	2026.18
Round Off Total Amount	2026.00

Certified that the particulars given above are true and correct

For SHRI SAMARTH TRADING COMPANY

**Bank Details**  
 Bank A/C: 579505040000105 Bank Name : Union Bank of India  
 Bank IFSC: UBIN0557951 Branch : Islampur

**Declaration :**  
 We declare that this invoice shows the actual price of the goods described and that all particulars are true and correct.

Company GSTIN/UIN : 27AMVPP2791E1ZG  
 Company PAN : AMVPP2791E



*Atabali*  
 Authorised signatory

# Shri Samarth Trading Company

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



GSTIN : 27AMVPP2791E1ZG

Date : 05/03/2019

Receipt No. : 540

Received with thanks from M/s. The principal,

Krishna Mahavidyalaya, Rethare BK

Rupees Eight thousand six Hundred forty  
six rupees only.

By Cash / D.D. / Cheque No. 024361 Date : 05/03/2019

In Part / Full / Advance Payment of Our Bill No. 0345/0346 Date : 1/120

**Rs.** 8646/-

Subject to realisation of cheque.

*CB*  
**Dr. C. B. Salunkhe**  
PRINCIPAL  
KRISHNA MAHAVIDYALAYA  
RETHARE (BK), TAL. KARAD

For Shri Samarth



Trading Company

No. **64** CASH MEMO Mob. 8600505861

# UMA STORES & XEROX

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

Shree श्री मालती कृष्ण शिंदे कारद  
Date 01/08/2019

Description	Total	Rate	Amount Rs. Ps
Glass cutter	01	120	120
<del>Pen</del>			
		Total-	120/-

one hundred twenty only

*Singh*  
Authorised sang.



THE UNIVERSITY OF CHICAGO  
LIBRARY

NO.	DATE	DESCRIPTION	AMOUNT
10	1900	...	...
11	1901	...	...
12	1902	...	...
13	1903	...	...
14	1904	...	...
15	1905	...	...
16	1906	...	...
17	1907	...	...
18	1908	...	...
19	1909	...	...
20	1910	...	...
21	1911	...	...
22	1912	...	...
23	1913	...	...
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# Krishna Mahavidyalaya, Rethare Bk.

Tal. Karad, Dist. Satara

Name of Tournament : Lead college workshop (Jr./Sr.)

Venue of : S.G.M. College, Karad

Date of Matches : 30 Oct, 2018

Sr. No.	Name of Student	T. A.		D. A.		Total		Signature of Student
		Rs.	Ps.	Rs.	Ps.	Rs.	Ps.	
1)	Mohini Rajendra Harale	50	00			50	00	<u>Salunke</u>
2)	Nikita Bharat Jadhav	50	00			50	00	<u>Jadhav</u>
3)	Dr. Dhanaji S. Dalavi	50	00			50	00	<u>Salunke</u>
<p>(Research promotion activity for student of affiliated colleges.)</p> <p>या योजनेसंदर्भात विद्यार्थ्यांसाठी कार्यशाळा.</p> <p>Research project of, ₹ 10,000/- मध्ये.</p>								
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Dr. C. B. Salunke  
PRINCIPAL

**Shivaji University, Kolhapur**  
**RESEARCH SENSITIZATION SCHEME FOR COLLEGE**  
**STUDENTS**

**UNDER LEAD COLLEGE, ACTIVITY**

**Submission of Project Report**

**Title of the Project: Fabrication of Nanostructured  
Polyaniline thin film for electrochromic smart  
windows and supercapacitor application.**

**By**

**Miss. Desavale Suryashree Vilasrao,**

**Mr. Jadhav Amol Vijay,**

**Miss. Mohini Harale Rajendra,**

**Miss. Jadhav Nikita Bharat**

**Under the Guidance of**

**Dr. Dhanaji S. Dalavi**

**Assistant Professor,**

**Krishna Mahavidyalaya, Rethare (Bk)**

**Academic Year: 2018-2019**

## DECLARATION

We hereby declare that, the project report entitled "**Fabrication of Nanostructured Polyaniline thin films for electrochromic window and supercapacitor 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: 27/02/2019

### Name of project students.

1. Desavale Suryashree Vilasrao. Desavale
2. Jadhav Amol Vijay Jadhav
3. Harale Mohini Rajendra. Harale
4. Jadhav Nikita Bharat. Jadhav

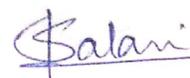
## CERTIFICATE

This is to certify that thesis entitled **“Fabrication of Nanostructured Polyaniline thin films for electrochromic window and supercapacitor application”** which is being submitted herewith is the result of original research work completed by **Miss. Desavale Suryashree Vilasrao, Mr. Jadhav Amol Vijay, Miss. Mohini Harale Rajendra, Miss. Jadhav Nikita Bharat** 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: 27/02/2019

Project Advisor



(Dr. Dhanaji S. Dalavi)

## 1 INTRODUCTION

Conducting polymers show the remarkable properties of combining properties of organic polymers in tandem with electronic properties of semiconductors. The ability to tailor the structure of a conjugated polymer allows the rational synthesis of conducting polymers with a broad range of electronic properties [1]. The electronic character of the polymer can be easily manipulated by changing the nature of the repeating unit and the functional groups. Over the past 25 years, the conducting polymers belonging to polyenes or polyaromatics such as polyaniline, polypyrrole, polythiophene, poly(*p*-phenylene) have attracted most attention [2,3]. New chemical and physical properties are imparted to conducting polymers by the addition of an appropriate functional group to a conventional polymer [4]. The character and position of the side chains will affect properties like solubility, band gap, ionic conductivity, morphology and miscibility with other substances [5]. The ability to dope conjugated polymers electrochemically is significant, because of the easy combination of synthesis and characterization methods. Electrochemically synthesized polymer allows the determination of molecular weight and molecular weight distribution. Many applications of conjugated polymers, such as light emitting electrochemical cells [6,7], microactuators [8,9], energy storage [10], photovoltaic[11] and electrochromic devices (ECDs) [12,13,14], and sensors [15] are based on electrochemical transition between doped and neutral states or rely on the stability of a specific doping level.

Of the many conducting polymers available, PANI is emerging as a novel material due to its techno-commercial applications and ease of synthesis [16]. Polyaniline (PANI) exists in a variety of forms that differ in chemical and physical properties [17–20]. The most common green protonated emeraldine has conductivity on a semiconductor level of the order of  $10 \text{ S cm}^{-1}$ , many orders of magnitude higher than that of common polymers ( $<10^{-9} \text{ S cm}^{-1}$ ) but lower than that of typical metals ( $>10^4 \text{ S cm}^{-1}$ ). The changes in physicochemical properties of PANI occurring in the response to various external stimuli are used in various applications [21–22], e.g., in organic electrodes, sensors, and actuators [23–25]. Other uses are based on the combination of electrical properties typical of semiconductors with materials parameters characteristic of polymers, like the development of “plastic” microelectronics [26], electrochromic devices [27], tailor-made composite systems [28,29], and “smart” fabrics [30].

The establishment of the physical properties of PANI reflecting the conditions of preparation is thus of fundamental importance by an occasionally expressed opinion that “there

are as many polyaniline as the number of people who prepare them". The efficient polymerization of aniline is achieved only in an acidic medium, where aniline exists as an anilinium cation. PANI film is a multichromic polymer i.e. several colors appear as the polymer traverses from the oxidized state to reduced state. Fully reduced PANI is transparent and called leucoemeraldine, with a chemical structure as shown in Figure 1. The dark blue semi-oxidized state in which both the forms are in equal proportion is named emeraldine base and the violet blue fully oxidized material is termed pernigraniline base. Unlike other polyaromatics, none of these states are electronically conducting, not even the fully oxidized pernigraniline form. Instead, PANI becomes conducting when the oxidized states are protonated and a green emeraldine salt is formed. This highly conducting doped form can actually be reached through two completely different pathways. If the emeraldine base is treated with any acid, protonic acid doping occurs as protonation of the imine nitrogen atoms  $-N=$ ) creates positively charged protonated imines ( $-NH^+$ ), balanced by negative ions from the acid. This is called as non-redox doping. Chemical or electrochemical doping of the reduced leucoemeraldine base can also be utilized to obtain the very same conducting salt [31]. Colorless leucoemeraldine which constitutes the bleached state is formed by chains of benzoid rings separated by nitrogen. This is in the insulating state with a single absorption band at 3.8 eV corresponding to  $\Pi-\Pi^*$  transitions in the benzoid rings. When the Nitrogen atoms become charged, a sharp polaron band appears at  $\sim 3\text{eV}$ . In ES, 1eV absorption is attributed to intrachain free carrier excitation [32] Anodically coloring PANI is reported to have high contrast and multichromic efficiency [33]. A variety of inorganic and organic acids of different concentration have been used in the syntheses of PANI; the resulting PANI, protonated with various acids, differs in solubility, conductivity, and stability. Higher acidity of the reaction medium also leads to the increase in the conductivity. Variation in pH on deposition of PANI is very profound. Acid doping of PANI leads to an increase in conductivity by more than eight orders of magnitude [34]. PANI obtained at lower potentials yield higher coloration yields. Over oxidation of PANI leads to degradation of polymer, so that is another parameter which needs to be looked into.

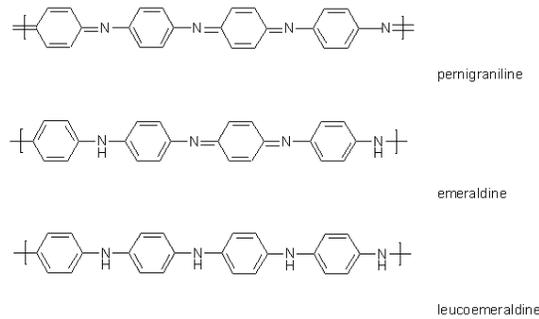


Fig.1. Various possible oxidation states of polyaniline.

The electrochromic process occurring in a PANI ECD in an electrolyte comprising of  $\text{LiClO}_4$  in a solvent like Propylene Carbonate and Acetonitrile can be written as



Many deposition methods like CBD, electrodeposition, dip coating, etc exist for the deposition of PANI films. However, the In-situ chemical polymerization approach has several advantages in that the conducting polyaniline blends and composites are supplied in the form of free standing films and also that the electrical properties of the composites can be modified by simply varying the conditions of electrolysis [31]. The chemical synthesis is clean. When PANI film is oxidized by chlorate ions, it turns bluish green due to formation of emeraldine base. PANI exists in the quinoid form in this case. When ions reduce the film, the PANI film achieves the insulating state changing from bluish green to transparent yellow due to the benzoid form. An ECD having the following configuration Glass/ITO/PANI/LiClO<sub>4</sub>+PC+ACN/Graphite was set up and tested for its coloration efficiency, response time and optical density.

## 2. Experimental Procedure and Characterization Technique.

In a typical experiment 0.5 g of PVA powder with an average degree of polymerization of 1750 was dissolved in 50 ml distilled water at 80 °C and stirred for an hour. An FTO electrode of 2 cm<sup>2</sup> with resistance of about 15–20 cm<sup>2</sup> was washed with distilled water and acetone successively. After drying the electrode at room temperature the PVA solution was casted onto FTO substrate to form a PVA thin film by spin coating method. The electrode coated with the PVA film is ready after drying at room temperature for one day. The polyaniline solution was prepared at room temperature using a chemical bath (In-situ chemical polymerization) consisting of ammonium persulphate (APS), hydrochloric acid (HCl), aniline and distilled water. 2ml of

aniline was dissolved into 30 ml of 1M HCl in a beaker. In another beaker 1.15 g of  $(\text{NH}_4)_2\text{S}_2\text{O}_8$  (APS) was dissolved in 20 ml of 1M HCl. The solution in the second beaker was poured slowly into the first beaker and PVA coated electrode was dipped into PANI solution for 10 min. After deposition, the electrodes were rinsed with distilled water for removing loosely bound PANI precipitate particles. The thickness of films increases by increasing the deposition cycles. The thin films of PVA/PANI were allowed to dry at  $100^\circ\text{C}$  for 5 h.

Prior to deposition, ITO glass substrates were given full cleaning treatment. First they were cleaned with distilled water, acetone, ethanol, isopropyl alcohol and ultrasonic bath. Then they were kept in the vacuum oven for 10 minutes. These cleaned ITO's were stored for further use of deposition of films. The number of cycles was varied in order to obtain smooth, well adherent films. SEM images were taken to obtain information regarding the morphology of PANI films. The films were characterized for the vibrational spectra using FT-RAMAN spectroscopy. The Fourier transform Raman (FT-Raman) spectra of the films were recorded in the spectral range of  $250\text{--}1000\text{ cm}^{-1}$  using FT-Raman spectrometer (Bruker MultiRAM, Germany) that employs Nd:YAG laser source with an excitation wavelength 1064 nm and resolution  $4\text{ cm}^{-1}$ . Electrochemical characterizations were carried out using electrochemical quartz crystal microbalance (EQCM) measurements (model-CHI-400A) made by CH Instruments, USA. Optical characterizations were carried out using UV-Vis spectrophotometer (UV 1800, Shimadzu, Japan). In-situ transmittance studies were carried out using a He-Ne Laser ( $\lambda=632.8\text{ nm}$ ), a Si photodiode and a storage oscilloscope. Colorimetric studies were done using computer controlled software for a  $2^\circ$  observer using D-65 illuminant. 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  $Y_{xy}$  co-ordinate 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  $2^\circ$  observer and D-65 illuminant proposed by CIE  $Y_{xy}$  and  $L^*a^*b^*$  coordinates.

### **3. Results and Discussion:**

#### **3.1 Scanning electron microscopy study**

The morphological features of PANI samples deposited by in-situ chemical bath deposition are shown in Fig.1. As the number of layers increases PANI thin films transfers its

morphology from smooth to granular structure which provide enough pathways for movement of ions and solvent molecules within the films, thereby improving its coloration efficiency [35].

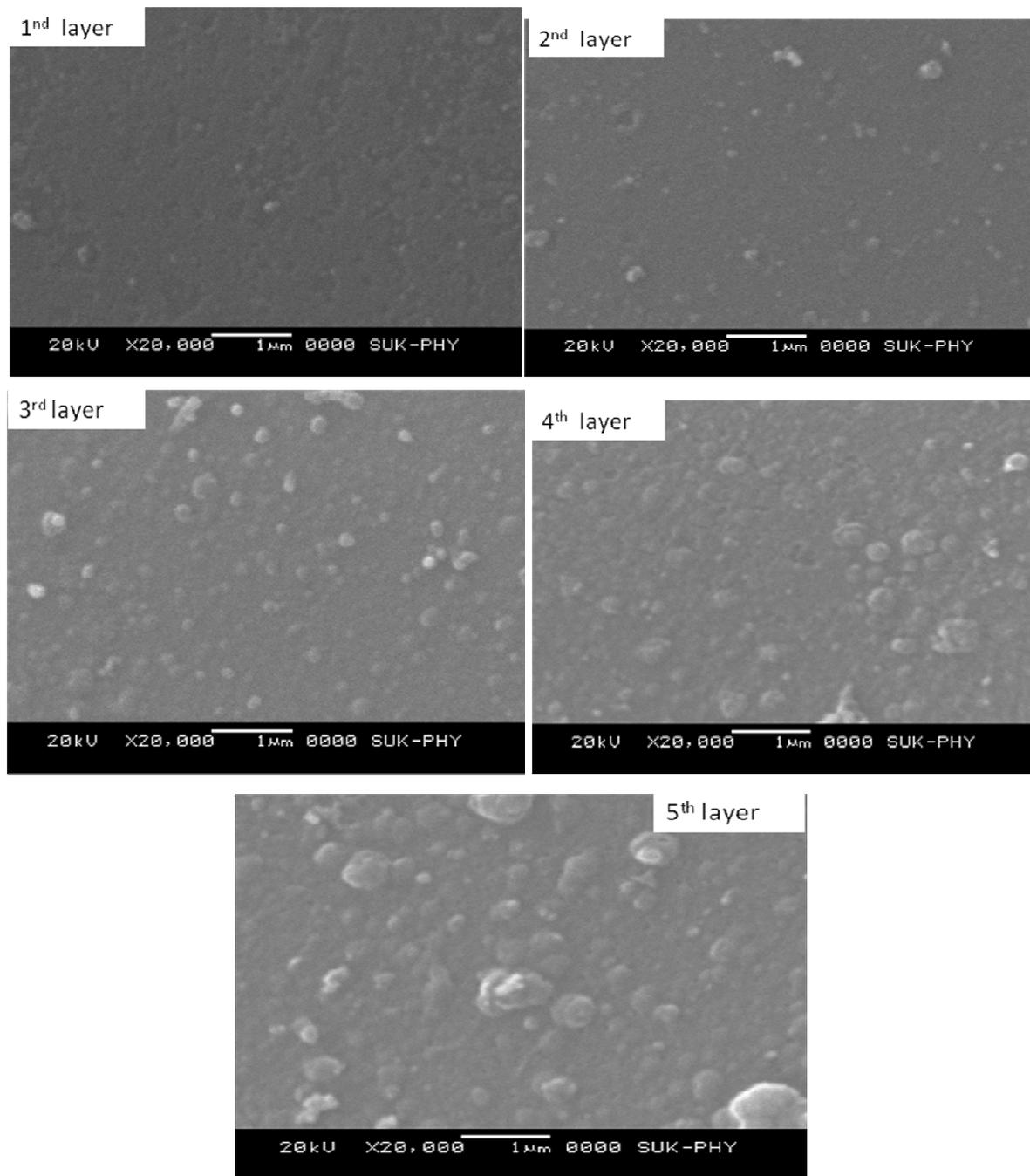
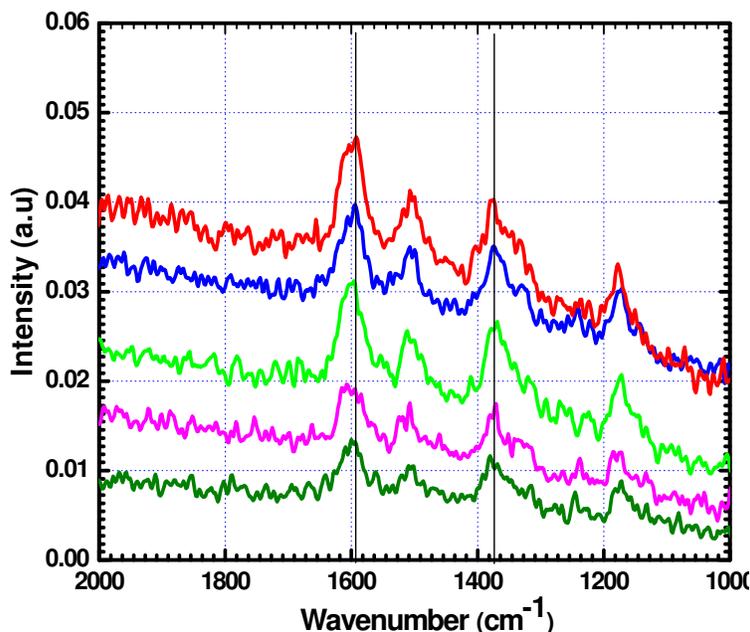


Fig.1 SEM images of PANI thin films

### 3.2 Raman Spectroscopy:

Raman spectroscopy is a powerful tool to understand the vibrational properties of molecules. It provides definite structural characterizations of PANI because of characteristic dependence of Raman spectrum on the ring constituents of aromatic compounds.

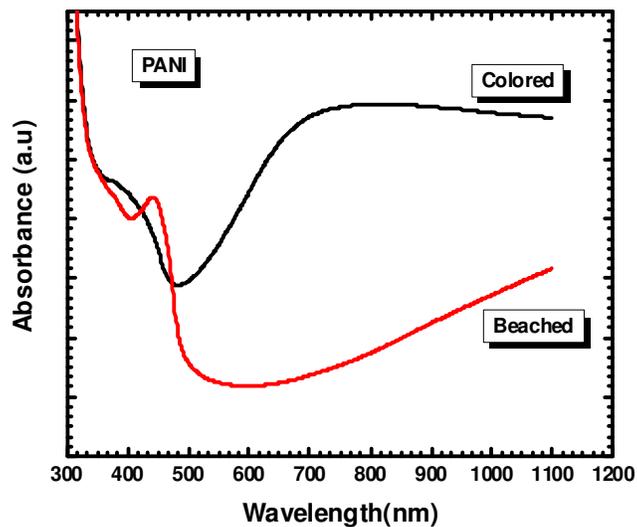


**Fig.2.** Raman spectra of PANI films deposited for different number of cycles.

Fig.2 shows the Raman spectra of PANI films deposited for different number of cycles. In the spectra, -C-H bending of quinoid ring at  $1180\text{ cm}^{-1}$ , -C-H bending of benzoid ring at  $1247\text{ cm}^{-1}$ , and C-C stretching of the benzene ring was observed at  $1498\text{ cm}^{-1}$  and  $1600\text{ cm}^{-1}$  respectively revealing the presence of doped emeraldine PANI structure [36,37].

### 3.3 Optical studies

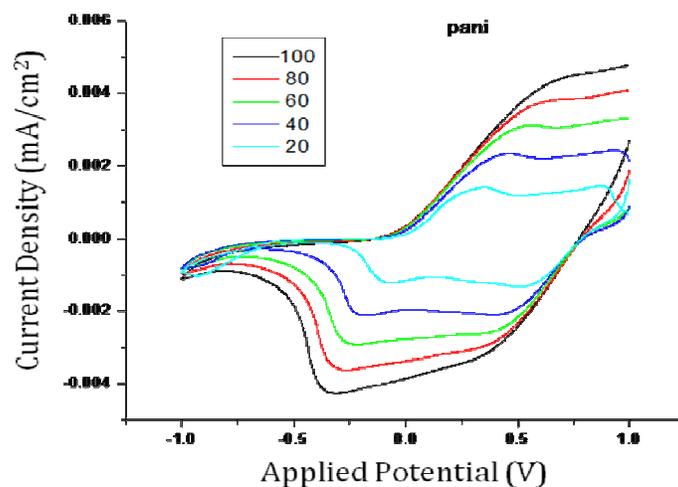
The UV-Vis absorbance spectra of PANI film was studied by measuring their visible absorption spectra in the range of 190-1100 nm range. The Fig.3 shows the absorbance vs wavelength studies of PANI thin film in two different states. In the as deposited state or the colored state, the absorbance spectra show a broad absorption peak at 600 nm. When insertion of  $\text{ClO}_4^-$  ions takes place, PANI turns to a transparent pale yellow color. The absorbance in this case is into the far NIR and the film appears transparent. Similar reports have been reported by other groups [38].



**Fig.3.** Absorption spectra of PANI (P5) sample in their colored and bleached state in the range of 190-1100 nm. Potential was swept from +1 V to -1 V vs SCE.

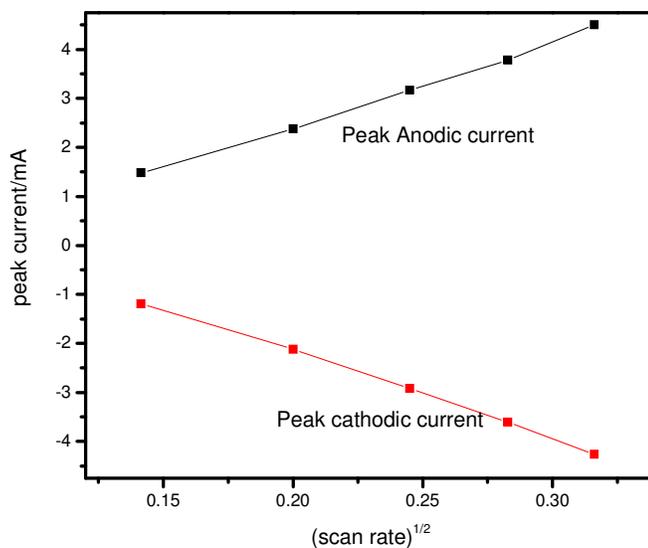
### 3.4 Cyclic voltammetry

Cyclic voltammetry of PANI films was performed in the three electrode cell in 0.5 M  $\text{LiClO}_4 + \text{PC} + \text{CAN}$  (Fig.4). A potential window of -1 to 1 V for cyclic voltammetry studies was chosen at different scan rates from 20mV/s to 100 mV/s. PANI film shows two cathodic peaks at +0.38 V (C1) and -0.28V (C2). Upon the reversal of the potential from -1 V to +1V two anodic peaks were observed at -0.45 V (A1) and +0.6 V (A2) respectively. The cyclic voltammetry was carried out at different scan rates to gather information about the intercalation/deintercalation kinetics.



**Fig.4** Cyclic voltammograms of PANI film recorded in 0.5 LiClO<sub>4</sub>+PC+CAN electrolyte. The potential swept from -1 to +1V versus SCE at the scan rate of 20 mV/sec to 100 mV/sec.

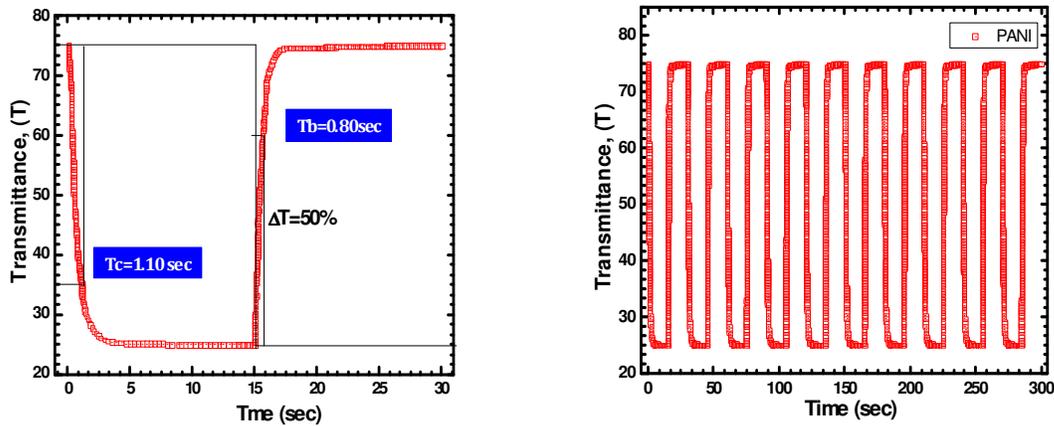
Fig.5 shows the plot of square root of scan rate vs the peak anodic and cathodic current. The linear curves show that the reaction is not limited by the ion mobility in the film. The diffusion coefficient calculated for the anodic and cathodic peak current were found to be  $6.7 \times 10^{-11} \text{ cm}^2/\text{s}$  and  $4.4 \times 10^{-11} \text{ cm}^2/\text{s}$



**Fig.5.** Graph showing linear variation of peak current with root of scan rate.

### 3.5 In-situ Transmittance-Response time studies:

In-situ characterizations of PANI films were carried out to find the transmittance modulation as a function of time. A square wave potential of  $\pm 1V$  was applied with a pulse width of 15s. Initially as deposited PANI is in the colored state. When a negative pulse of  $-1V$  was applied, the film switched from its conducting emeraldine state to transparent leucoemeraldine state. The bleaching time is defined as the time taken for the transmittance to change from 0 to 80% of its maximum value. This switching time referred to as bleaching time  $t_b$  as seen from the graph was found to be 0.80 s. In the reverse cycle, on the application of a positive pulse, the film started to regain its colored state. This time is referred to as coloring time  $t_c$ . The coloring time is defined as the time taken for the film transmittance to change from 100% to 20% of its maximum value. This time was found to be 1.10 s. Such fast response time makes the conducting polymers ideal candidates for switching applications.



**Fig.6** In-Situ Transmittance-Time response of PANI thin film in colored and bleached state a) for one cycle b) for 10 cycles.

### 3.6 Coloration Efficiency

The coloration efficiency ( $\eta$ ) at a particular wavelength correlates with the optical contrast, i.e. the change in optical density with charges intercalated per unit electrode area ( $q/A$ ) and it can be expressed as:

$$C.E = \frac{\Delta OD}{Q_i} = \frac{2.303 \log \frac{T_b}{T_c}}{q/A} \text{----- (3)}$$

where  $T_b$  and  $T_c$  are the transmittance in the colored and bleached state and  $Q_i$  is the number of charges into the film. The coloration efficiency was found to be  $90.60 \text{ cm}^2/\text{C}$

### 3.7 Colorimetric studies

Fig.7 shows the PANI films were characterized using color software for a  $2^\circ$  observer using D-65 illuminant. The values of Lab are listed in the table.1. The xy value plotted for different values of the applied potential. Unlike other polymers, PANI exhibits a parabolic curve on the chromaticity diagram. The trajectory of PANI film follows a curved path is shown in the chromaticity diagram. In the initial state, when PANI is in as deposited condition, it exhibits a bluish green color. As the applied negative potential increases, the color of the film changes from blue to green. With further increase in the negative potential, the film becomes light yellow or nearly transparent in color. The Lab values in the initial and final stages are listed in the table.1. In the colored state, L value is 57.17 i.e: in this case, the transmittance is low. The negative value of 'a' at -11.44 and a high value of 'b' at 26.59 signify the bluish green tinge in the film. In the bleached state, the L value changes to 86.25 signifying an increase in transparency of the film. The value of 'a' and 'b' now fall down to -2.77 and 7.65 indicating a weak yellow color. The dominant wavelength is found by drawing a straight line from the white point through the position of the point at a specific coordinate. In the transparent state this wavelength is given by 575 nm. In the colored state, the dominant wavelength is found to be 500 nm. The changes in L values in the colored and bleached state give the transmittance attenuation. This change in transmittance is found to be 31.78.

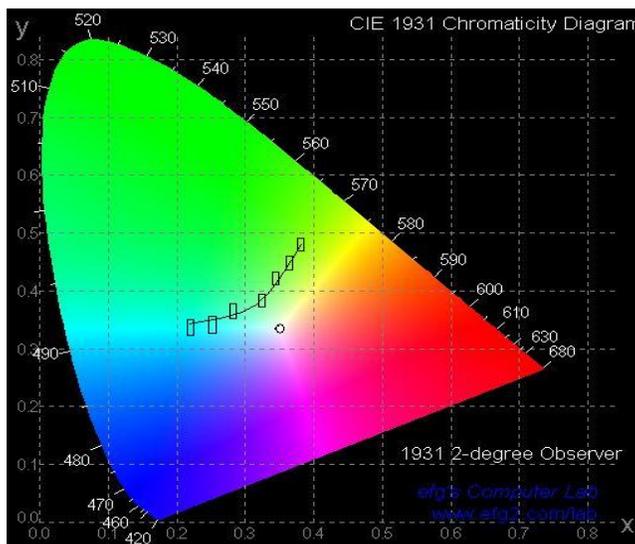


Fig.7. CIE 1931 xy chromaticity diagrams for oxidation/reduction (colored/bleached) of PANI thin film.

#### **4 Conclusions**

PANI films were successfully deposited by in-situ chemical polymerization. The films had a smooth surface with a good adherence to the substrate. The thickness of the films was varied with the number of cycles. SEM studies show transfer from smooth to granular structure of in-situ chemically polymerized PANI films with increase in deposition cycle which are advantageous for easy ion insertion /extraction. Raman spectra show the characteristic stretching and bending vibrations. ECD comprising of PANI films show an optical modulation of 50 %. The device shows a fast response time of 1.10 sec and 0.80 sec for coloring and bleaching respectively. The films show a large variation of 31.78 in  $L^*$  value showing a good optical modulation.

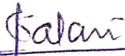
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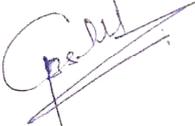
1. J.R. Reynolds, A. Kumar, J.L. Reddinger, B. Sankaran, S.A. Sapp, G.A. Sotzing, *Synth. Met.* 85 (1997) 1295.
2. D. Kumar, R.C. Sharma, *Eur. Polym. J.* 34 (1998) 1053.
3. L.B. Groenendaal, F. Jonas, D. Freitag, H. Pielartzik, J.R. Reynolds, *Adv. Mater.* 12 (2000) 481.
4. A. Cirpan, S. Alkan, L. Toppare, Y. Hepuzer, Y. Yagci, *J. Poly. Sci.: Part A: Poly. Chem.* 40 (2002) 4131.
5. T. Johansson, W. Mammo, M. Svensson, M. Andersson *J. Mater. Chem.* 13 (2003) 1316.
6. Q. Pei, G. Yu, C. Zhang, Y. Yang, A.J. Heeger, *Science.* 269 (1995) 1086.
7. T. Johansson, W. Mammo, M. Svensson, M.R. Andersson, *Chem. Mater.* 11(1999) 3133
8. Q. Pei, H. Jarvinen, J.E. Osterholm, O. Inganaes, J. Laakso, *Macromolecules.* 25 (1992) 4297.
9. E.W.H. Jager, O. Inganas, I. Lundström, *Science.* 288 (2000) 2335.
10. Y. Gofer, J.G. Killian, H. Sarker, T.O. Poehler, P.C. Searson, *J. Electroanal. Chem.* 443 (1998) 103.
11. T. Yohannes, O. Inganas, *J. Electrochem. Soc.* 143 (1996) 2310.
12. E. Sahin, P. Camurlu, L. Toppare, V.M. Mercore, I. Cianga, Y. Yagci, *Electroanal. Chem.* 579 (2005) 189.
13. E. Aslan, P. Camurlu, L. Toppare, *J. Macromol. Sci., Pure Appl. Chem.* A42 (4) (2005) 451.
14. G. Sonmez, H. Meng, F. Wudl, *Chem. Mater.* 16(2004) 574.
15. J. Bobacka, *Anal. Chem.* 71 (1999) 4932.
16. S. Shreepathi [Dodecylbenzenesulfonic Acid: A Surfactant and Dopant for the Synthesis of Processable Polyaniline and its Copolymers: Thesis.
17. A. G. MacDiarmid and A. J. Epstein. *Faraday Discuss. Chem. Soc.* 88 (1989) 317.
18. J. Stejskal, P. Kratochvil, A. D. Jenkins. *Polymer* 37 (1996) 367.
19. D. C. Trivedi. In *Handbook of Organic Conductive Molecules and Polymers*, H. S. Nalwa (Ed.), Wiley, Chichester 2 (1997) 505.
20. N. Gospodinova and L. Terlemezyan. *Prog. Polym. Sci.* 23 (1998) 1443.
21. B. G. Levi. *Phys. Today* 53 (12) (2000) 19.
22. A. G. MacDiarmid. *Angew. Chem., Int. Ed.* 40(2001) 2581.
23. Z. Jin, Y. Su, Y. Duan. *Sens. Actuators B* 72(2001) 75.
24. P. T. Sotomayor, I. M. Raimundo, A. J. G. Zarbin, J. J. R. Rohwedder, G. O. Netto, O. L. Alves. *Sens. Actuators B* 74(2001) 157.
25. L. A. P. Kane-Maguire and G. G. Wallace. *Synth. Met.* 119(2001) 39.
26. R. J. Hamers. *Nature* 412 (2001) 489.
27. D. R. Rosseinsky and R. J. Mortimer. *Adv. Mater.* 13(2001) 783.
28. J. Prokes, I. Krivka, E. Tobolkova, J. Stejskal. *Polym. Degrad. Stab.* 68 (2000) 261.

29. G. K. Elyashevich, L. Terlemezyan, I. S. Kuryndin, V. K. Lavrentyev, P. Mokreva, E. Yu. Rosova, Yu. N. Sazanov. *Thermochim. Acta* 374 (2001) 23.
30. M. A. El-Sherif, J. Yuan, A. G. MacDiarmid. *J. Intelligent Mater. Syst. Struct.* 11 (2000) 407.
31. J. Anand, S. Palaniappan, and D. N. Sathyanarayana, *Prog. Polym. Sci.* 23 (1998)993.
32. A. G. MacDiarmid and A. J. Epstein. *Faraday Discuss. Chem. Soc.* **88**(1989) 317.
33. L. Zhang, S. X. Xiong, J. Ma, X. Lu, *Solar. Ener. Mater. Sol. Cells* 93 (2009) 625.
34. J. C. Chiang, A. G. MacDiarmid, *Synth. Met.*, 13 (1986) 193.
35. C. Peng, J. Jin, G. Z. Chen, *Electrochimica acta.* 53 (2007) 525.
36. D. S. Patil, J. S. Shaikh, D. S. Dalavi, S. S. kalagi, P. S. Patil, *Mat. Chem and Phy* 128 (2011) 449.
37. X. B. Yan, Z. J. Han, Y. Yang, B. K. Tay, *Sensors and actuators B* 123 (2007)107.
38. X. F. Yu, Y. X. Li, N. F. Zhu, Q. B. Yang, and K. Kalantar-zadeh, *Nanotechnology* 18 (2007) 015201

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