

Gaurav Lohar <gauravlohar24@gmail.com>

Fri, Apr 27, 2018 at 11:05 AM

SERB-Notification

Dr. Magesh KK <mageshkk@serb.gov.in> To: "info@serbonline.in"@imsva02.cdacnoida.in



Science and Engineering Research Board

(Statutory Body Established Through an Act of Parliament : SERB Act 2008) Department of Science and Technology, Government of India

SCIENCE & ENGINEERING RESEARCH BOARD (SERB)

(Statutory Body Established Through an Act of Parliament : SERB Act 2008)

Science and Engineering Research Board 5 & 5A, Lower Ground Floor Vasant Square Mall Sector-B, Pocket-5 Vasant Kunj New Delhi - 110 070

Approval Letter

File Number: ECR/2017/002099

Dated: 27-Apr-2018

Subject: Project titled "Performance and evaluation of high energy electron irradiation on metal oxide reduced graphene oxide composite for supercapacitor and biosensor applications".

Dear Dr. Gaurav Mahadev Lohar,

The project cited above has been recommended by the related **Early Career Research Award** to the Science and Engineering Research Board (SERB) for funding. The following are the items recommended for a period of 3 years. The final budget to be sanctioned would be based on quotations received, existing norms, funds availability etc.

The committee recommended the following budget

Manpower : JRF-1 Equipment Details : As proposed -> Ultrasonic Sonicator (Probe sonicator) - 1 -> Hydrothermal unit with high pressure autoclave - 1 -> Vacuum furnace - 1 -> Double distilled water plant - 1 -> Weight balance (0.1mg) - 1 Consumables : As proposed Travel Cost : As per norms Contingencies : As per norms Overhead : As per norms

Kindly follow the below steps only then you will be able to acknowledge the approval letter :

1. Go to www.serbonline.in through your credentials

2. Go to Menu --> Proposal submission --> View submitted proposals

3. Click on the link under Status column "Proposal Approved, Acknowledgment pending from PI"

https://mail.google.com/mail/u/0?ik=4760e63125&view=pt&search=all&permmsgid=msg-f%3A1598876394721593561&simpl=msg-f%3A15988763947... 1/2

REQUEST FOR ANNUAL INSTALMENT WITH UP-TO-DATE STATEMENT OF EXPENDITURE

1.	SERB Sanction Order No and date	: ECR/2017/002099 (27/04/2018)
2.	Name of the PI	: Dr. Gaurav Mahadev Lohar
3.	Total Project Cost	: 21,68,085/-
4.	Revised Project Cost (if applicable)	: Nil
5.	Date of Commencement	: 06/10/2018

6. Statement of Expenditure

i. (Month wise expenditure incurred during current financial year)

Month & year	Expenditure incurred/ committed
April-2020	17,600/-
May-2020	17,600/-
June-2020	17,600/-
July-2020	17,600/-
August-2020	19,478/-
September-2020	30,200/-
October-2020	48,337/-
November-2020	69,871/-
December-2020	28,402/-
January-2021	48,069/-
February-2021	22,820/-
March-2021	1,00,817/-
Total	4,38,394/-

7. Grant received in each year:

1

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a. 1st Year

r : 10,50,287/-

- b. 2nd Year : 1,50,000/-
- c. 3rd Year : 2,50,000/-
- d. Interest, if any : 7965/-

e. Total (a + b + c + d) : 14,58,252/-

8. Statement of Expenditure

(to be submitted financial year wise i.e. DOS* to 31st March of that financial year say 20, 01-04-20XX till 31.03.20XX+1year and so on)

		Total	Expenditure Incurred		Total	Balance as	Requireme		
Sr.	Sanctioned	Funds	1 st Year (1 st	2 nd Year	3 rd Year	Expenditure	on (date)	nt of Funds	Remarks
No.	Heads	Allocated	April to 31st	(1 st April to	& so on	till		up to 31 st	(if any)
		sanctioned	March of next	31 st March	(1 st April			March	
		or revised	year)	of next	to 51" March of		~	next year	
				ycar)	next year)				
(I)	(II)	(III)	(IV)	(V)	(VI)	(VII = IV + V + VI)	(VIII =III -VII)		
1.	Manpower costs	10,29,600/-	91,974/-	2,11,200/-	2,22,695/-	5,25,869/-	5,03,731/-	2,69,500/-	
2.	Consumables	1,50,000/-	-	50,000/-	50,000/-	1,00,000/-	50,000/-	50,000/-	
3.	Travel	1,50,000/-	26,118/-	23,882/-	50,000/-	1,00,000/-	50,000/-	50,000/-	
4.	Contingencies	1,50,000/-	23,882/-	26,118/-	50,000/-	1,00,000/-	50,000/-	50,000/-	
5.	Others, if any	-	-	-	-	-	-	-	
6.	Equipment	4,91,388/-	3,41,728/-	1,49,624/-	-	4,91,352/-	36/-	-	
7.	Overhead expenses	1,97,097/-	-	65,699/-	65,699/-	1,31,398/-	65,699/-	65,699/-	
8.	Total	21,68,085/-	4,83,702/-	5,26,523/-	438394/-	1448619/-	7,19,466/-	4,85,199/-	

M.No.183801

FRN No.

4709814

Name and Signature of Principal Investigator: Dr. G. M. Lohar Dr. G. M. LOHAR Signature of Competent financial authority: Date: 31/03/2021 **Project Investigator** (with seal) Date: 31/03/2021 **DST-SERB** Project Department of Physics NOMO - 21283801AAAAANG296 Lal Bahadur Shastri College of Arts, Science & Commerce, Satara

* DOS - Date of Start of project

Note:

Expenditure under the sanctioned heads, at any point of time, should not exceed funds allocated under that head, without prior approval of SERB i.e. Figures in Column (VIII) should not exceed corresponding figures in Column (III).
Utilization Certificate (Annexure III) for each financial year ending 31St March has to be enclosed along with request for carry-

forward permission to the next financial year.

NON-RECURRING GFR 12 – A [(See Rule 238 (1))] UTILIZATION CERTIFICATE (UC) FOR THE YEAR 2020-2021 in respect of NON-RECURRING as on 31st march 2021 to be submitted to SERB UC Audited.

1. Name of the grant receiving Organization: Lal Bahadur Shastri College of Arts, Science & Commerce, Satara

2. Name of Principal Investigator (PI): Dr. Gaurav Mahadev Lohar

3. SERB Sanction order no. & date: ECR/2017/002099 (25/04/2018).

4. Title of the Project: Performance and evaluation of high energy electron irradiation on metal oxide reduced graphene oxide composite for supercapacitor and biosensor applications.

5. Name of the SERB Scheme: ECR

6. Whether recurring or non-recurring grants: non-recurring grants

· 7. Grants position at the beginning of the Financial year (Grants released by SERB)

(i) Cash in Bank Carry forward from previous financial year : 13,249/-

(ii) Others, If any : Nil

(iii) Total : 13,249/-

Unspent Balance of Grants received previous years [figure as at SI. No. 7(iii)]	Interest Earned thereon	Interest deposited back to the SERB	Grants received during the year		Total Available funds (1+2-3+4)	Expenditure incurred	Closing Balances	
(1)	(2)	(3)		(4)		(5)	(6)	(5-6)
13,249/-	Nil	Nil	Sanction No. (i) Nil	Date (ii) Nil	Amount (iii) Nil	13,249/-	Nil	13,249/-

8. Details of grants received, expenditure incurred and closing balances: (Actuals)

Component wise utilization of grants:

Grant-in-aid-creation for capital assets	Total
Nil	Nil

Details of grants position at the end of the year

- (i) Cash in Hand/Bank
- (ii) Refunds to SERB, If any

- : 13,249/-: Nil : 13,249/-
- (iii) Balance (Carry forward to next financial year)

Signature of PI Dr. G. M. Lohar. Dr. G. M. LOHAR Project Investigator DST=SERB Project Department of Physics Lal Bahadur Shastri College of Arts, Science & Commerce, Satara

Signature with Seal Name: N. B. Patil Chief Finance Officer (Head of Finance) Registrar Lal Bahadur Shastri College of Arts, Science & Commerce, Satara

Signature with Seal Name: Dr. R. V. Shejwal Head of Organization **PRINCIPAL**

Lal Bahadur Shastri College of Arts, Science & Commerce, Satara

NON-RECURRING GFR 12 – A [(See Rule 238 (1))] UTILIZATION CERTIFICATE (UC) FOR THE YEAR 2020-2021 in respect of NON-RECURRING as on 31st march 2021 to be submitted to SERB UC Audited.

Certified that I have satisfied that the conditions on which grants were sanctioned have been duly fulfilled/are being fulfilled and that I have exercised following checks to see that the money has been actually utilized for the purpose for which it was sanctioned:

- (i) The main accounts and other subsidiary accounts and registers (including assets registers) are maintained as prescribed in the relevant Act/Rules/Standing instructions (mention the Act/Rules) and have been duly audited by designated auditors. The figures depicted above tally with the audited figures mentioned in financial statements/accounts.
- (ii) There exist internal controls for safeguarding public funds/assets, watching outcomes and achievements of physical targets against the financial inputs, ensuring quality in asset creation etc. & the periodic evaluation of internal controls is exercised to ensure their effectiveness.
- (iii) To the best of our knowledge and belief, no transactions have been entered that are in violation of relevant Act/Rules/standing instructions and scheme guidelines.
- (iv) The responsibilities among the key functionaries for execution of the scheme have been assigned in clear terms and are not general in nature.
- (v) The benefits were extended to the intended beneficiaries and only such areas/districts were covered where the scheme was intended to operate.
- (vi) The expenditure on various components of the scheme was in the proportions authorized as per the scheme guidelines and terms and conditions of the grants-in-aid.
- (vii) It has been ensured that the physical and financial performance under ECR. (Name of the scheme has been according to the requirements, as

prescribed in the guidelines issued by Govt. of India and the performance/targets achieved statement for the year to which the utilization of the fund resulted in outcomes given at Annexure

- I duly enclosed.

- (viii) The utilization of the fund resulted in outcomes given at Annexure–II duly enclosed (to be formulated by the Ministry/Department concerned as per their requirements/specifications.)
- (ix) Details of various schemes executed by the agency through grants-in-aid received from the same Ministry or from other Ministries is enclosed at Annexure –II (to be formulated by the Ministry/Department concerned as per their requirements/specifications).

Date: 31/03/2021

Place: Satara

21 Signature of PI Signature with Seal Signature with Seal Dr. G. M. Lohar. Name: N. B. Patil Name: Dr. R. V. Shejwal Dr. G. M. LOHAR **Chief Finance Officer** Head of Organization **Project Investigator** (Head of Finance) DST-SERB Project PRINCIPAL Department of Physics Lal Bahadur Shastri College of Lal Bahadur Shastri College of Lal Bahadur Shastri College of Arts, Science & Commerce, Satara Arts, Science & Commerce, Satara Arts, Science & Commerce, Satara

NON-RECURRING GFR 12 – A [(See Rule 238 (1))] UTILIZATION CERTIFICATE (UC) FOR THE YEAR 2020-2021 in respect of *NON-RECURRING* as on 5th October 2021 to be submitted to SERB UC Audited.

- 1. Name of the grant receiving Organization: Lal Bahadur Shastri College of Arts, Science & Commerce, Satara
- 2. Name of Principal Investigator (PI): Dr. Gaurav Mahadev Lohar
- 3. SERB Sanction order no. & date: ECR/2017/002099 (25/04/2018).
- 4. **Title of the Project:** Performance and evaluation of high energy electron irradiation on metal oxide reduced graphene oxide composite for supercapacitor and biosensor applications.
- 5. Name of the SERB Scheme: ECR
- 6. Whether recurring or non-recurring grants: non-recurring grants
- 7. Grants position at the beginning of the Financial year (Grants released by SERB)
 - (i) Cash in Bank Carry forward from previous financial year : Nil
 - (ii) Others, If any : Nil
 - (iii) Total : Nil

o. Detai	is of grants received	expenditure incurred a	nd . 1	
Inspent Dolongo		experience incurred a	nd closing balances:	(Actuals)
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of Grants received previous years [figure as at SI. No. 7(iii)]	Interest Earned thereon	Interest deposited back to the SERB	Grants received during the year		Total Available funds (1+2-3+4)	Expenditure incurred	Closing Balances	
(1)	(2)	(3)		(4)				
NI:1			Sanction No. (i)	(4) Date (ii)	Amount (iii)	(5)	(6)	(5-6)
INII	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Component wise utilization of grants:

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Grant-in-aid-creation for capital assets	Total		
Nil	Nil		

Details of grants position at the end of the year

- (i) Cash in Hand/Bank
- : Nil (ii) Refunds to SERB, If any : Nil
- Balance (Carry forward to next financial year) (iii) : Nil



Signature with Seal Name: N. B. Patil **Chief Finance Officer** (Head of Finance) Registrar Lal Bahadur Shastri College of Arts, Science & Commerce, Satara

Signature with Seal Name: Dr. R. V. Shejwal Head of Organization PRINCIPAL Lal Bahadur Shastri College of Arts, Science & Commerce, Satara

NON-RECURRING GFR 12 – A [(See Rule 238 (1))] UTILIZATION CERTIFICATE (UC) FOR THE YEAR 2020-2021 in respect of *NON-RECURRING* as on 5th October 2021 to be submitted to SERB UC Audited.

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- (i) The main accounts and other subsidiary accounts and registers (including assets registers) are maintained as prescribed in the relevant Act/Rules/Standing instructions (mention the Act/Rules) and have been duly audited by designated auditors. The figures depicted above tally with the audited figures mentioned in financial statements/accounts.
- (ii) There exist internal controls for safeguarding public funds/assets, watching outcomes and achievements of physical targets against the financial inputs, ensuring quality in asset creation etc. & the periodic evaluation of internal controls is exercised to ensure their effectiveness.
- (iii) To the best of our knowledge and belief, no transactions have been entered that are in violation of relevant Act/Rules/standing instructions and scheme guidelines.
- (iv) The responsibilities among the key functionaries for execution of the scheme have been assigned in clear terms and are not general in nature.
- (v) The benefits were extended to the intended beneficiaries and only such areas/districts were covered where the scheme was intended to operate.
- (vi) The expenditure on various components of the scheme was in the proportions authorized as per the scheme guidelines and terms and conditions of the grants-in-aid.
- (vii) It has been ensured that the physical and financial performance under **ECR.** (Name of the scheme has been according to the requirements, as prescribed in the guidelines issued by Govt. of India and the performance/targets achieved statement for the year to which the utilization of

prescribed in the guidelines issued by Govt. of India and the performance/targets achieved statement for the year to which the utilization of the fund resulted in outcomes given at Annexure

- I duly enclosed.

- (viii) The utilization of the fund resulted in outcomes given at Annexure–II duly enclosed (to be formulated by the Ministry/Department concerned as per their requirements/specifications.)
- (ix) Details of various schemes executed by the agency through grants-in-aid received from the same Ministry or from other Ministries is enclosed at Annexure –II (to be formulated by the Ministry/Department concerned as per their requirements/specifications).

Date: 05/10/2021

Place: Satara

pulm Signature of PI Signature with Seal Signature with Seal Dr. G. M. Lohar Name: N. B. Patil Name: Dr. R. V. Shejwal Dr. G. M. LOHAR **Chief Finance Officer** Head of Organization Project Investigator (Head of Finance) DST-SERB Project PRINCIPAL Department of Physics Lal Bahadur Shastri College of Lal Bahadur Shastri College of 1 al Bahadur Shastri College of Arts, Science & Commerce, Satara Arts, Science & Commerce, Satara . Juliance & Commerce, Satara

Closure Report

File Number :	ECR/2017/002099				
Project Title :	Performance and evaluation of high energy electron irradiation on metal oxide reduced graphene oxide composite for supercapacitor and biosensor applications				
Principal Investigator :	Dr. Gaurav Mahadev Lohar				
	Lal Bahadur Shastri College of Arts, Science and Commerce, Satara 17 malhar peth, Satara ,MAHARASHTRA-415002				
Total Sanctioned Amount :	21,68,085 (INR)				
Total Released Amount :	17,20,287 (INR)				
Start Date of the Project:	06 Oct, 2018				
Date of completion:	05 Oct, 2021 (36 months)				
Approved Objectives :					

• To study the supercapacitance and biosensing performance of electron irradiated metal oxide reduced graphene oxide composite. To study the supercapacitance and biosensing performance of MnO2/rGO, NiO/rGO and Co3O4/rGO thin films. To synthesis and irradiate optimized metal oxide reduced graphene oxide based composite on flexible substrate for device fabrication. To fabricate flexible supercapacitor and biosensor devices, for fulfill the need of energy storage and development of biomedical analytical tools. **Deviation made from original objectives (If Any) :**

Nil		
Ph.D. Produced/ Likely to be Pr	oduced	: 1
Technical Personnel Trained	:	1
Total Expenditure :	17,86,311 (INR)
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Concise Research Accomplishment :

have successfully synthesized graphene oxide by using Modified Hummers method. Hydrothermal method is most suitable synthesis process for the preparation of nanomaterials, nanostructures, and nanocomposites of metal, alloys, ceramic, organic, and polymers, etc., with various morphologies, compared to other methodologies. Hence, we adopted hydrothermal method for the synthesis of Co3O4/rGO, NiO/rGO and MnO2/rGO nanocomposites. The hydrothermally synthesized Co3O4/rGO composite shows highest specific capacitance of 454.2 F g-1 at 1 mA cm-2. The prepared supercapacitor electrode exhibited excellent cyclic stability of 90.16% over 10000 cycles. In case of non-enzymatic glucoses sensing of Co3O4/rGO, the electrode achieved 5.8324 mA mM-1 cm-2 glucose sensitivity. In case of hydrothermally synthesized NiO/rGO, the different NiO/rGO composites was obtained by varying GO concentration. The highest specific capacitance of 727.1 F g-1 at 1 mA cm-2 applied current density was achieved by NiO/rGO composite. Also, it exhibited good cyclic stability of about 80.4% after 9000 cycles. The symmetric solid state supercapacitor device prepared by using optimized NiO/rGO composite can showed excellent cyclic stability of 80.4% over 5000 cycles and can glow red LED. In the case of nonenzymatic glucose sensing, the optimized NiO/rGO composite exhibited the maximum 442.4 A mM-1 cm-2 glucose sensitivity compared to other electrodes with $R^2 = 0.9964$ and LOD of 7.42 M. The MnO2/rGO composite showed maximum specific capacitance of 259.2 F g-1 at a current density of 0.5 mA cm-2. The optimized electrode reported an extraordinary cyclic stability of 95.7% over 10000 cycles. The overall study reveals that all the prepared composite electrodes show excellent electrochemical supercapacitor as well as nonenzymatic glucose biosensing properties. In same project, effect of electron irradiation will be studied and results will be submitted after completing the experiment.

Closure Details

Experimental/ Theoretical Investigation carried out

1 Synthesis of graphene oxide Graphene oxide was synthesized by using Modified Hummers method. In actual experiment 5.0 g of graphite powder, 2.5 g of sodium nitrate, 115 mL sulfuric acid placed in an ice bath and stirred for 15 min. Then, 15 g of potassium permanganate was slowly added to mixture and stirred for 2 h. The mixture solution was transferred to a water bath (35°C) and stirred for 30 min. Afterward 230 mL of double distilled water (DDW) was added into the solution slowly and the solution temperature monitored was about 98°C and stirred for 15 min. Then deionized water (700 mL) and H2O2 (50 mL, 30%) was added to the solution respectively. The obtained suspension was washed by diluted HCl (5%) and DDW several times to achieve Ph about 7 and dried at 60°C. 2 Cobalt oxide 2.1 Synthesis of Co3O4 powders The Co3O4 powders were prepared by the hydrothermal method and the effect of reaction time was investigated. In actual synthesis, 0.1 M Co (NO3)2 6H2O and 0.2 M urea was dissolved in 80 mL of DDW with continuous magnetic stirring. Then ammonia was added in solution dropwise up to pH = 11. Then the solution was further stirred for another 30 minutes for the homogeneous distribution of components. Subsequently, the solution was transferred into a 100 mL Teflon-lined autoclave. The autoclave was placed in a hot air oven at 16, 18, 20, and 22 hours at 180°C. The autoclave was cooled to room temperature after the reaction time was completed. Eventually, the reaction products were removed from the autoclave washed several times with ethanol and DDW, dried overnight in a hot air oven at 60°C. The prepared powders were also annealed for 2 hrs at 400°C. The obtained powders at reaction times 16, 18, 20, and 22 h is denoted as P-16, P-18, P-20, and P-22, respectively. 2.2 Preparation of working electrode Firstly, stainless steel (SS) substrates (5 cm \times 1 cm) were mirror-polished using zero grade polish paper, washed with detergent and DDW. After washing they were ultrasonically cleaned for 15 minutes and finally dried. The working electrode for the supercapacitor study was prepared by mixing powders P-16. P -18, P -20, and P -22 as an active material and polyvinylidene difluoride (PVDF) as a binder in mass ratio 80:20 in N-Methyl-2-Pyrrolidone (NMP) as a solvent. Then this prepared slurry was pasted on SS substrate by the doctor blade method and dried out at 60°C overnight. The resulting electrodes were named T-16, T-18, T-20, and T-22, respectively. Similarly, for non-enzymatic Glucose sensing a small piece ($2 \text{ cm} \times 1 \text{ cm}$) of CC was treated ultrasonically with acetone, ethanol, and DDW each for 15 min, respectively. Then this ultrasonicated CC dried out overnight at 60°C in a hot air oven. The working electrode was prepared by mixing powders P-16. P-18, P-20, and P-22 as an active material and PVDF as a binder in mass ratio 80:20 in NMP as a solvent. Then this prepared slurry was pasted on CC by the doctor blade method and dried out at 60°C overnight. The resulting electrodes were named TC-16, TC-18, TC-20, and TC-22, respectively. 3 Co3O4/rGO composite 3.1 Synthesis of Co3O4/rGO powders The Co3O4/rGO nanostructures by varying GO concentration were synthesized by using the hydrothermal route. In synthesis, 1.74 g of Co (NO3)2 6H2O and 3.6036 g urea was added in 30 mL DDW. Different amounts of GO powder (0, 30, and 60 mg) were added in 30 mL DDW in a separate beaker and ultrasonicated for 1 h. Then, these solutions were mixed and kept on constant starring for 1h. The obtained homogeneous solution was poured into a Teflon liner, sealed in autoclave and maintained at 120°C for 6 h. Afterwards, the product was cleaned with DDW and ethanol many times and dried at 60°C for 12 h. Lastly, the resulted powders annealed at 400°C for 2 h. Based on GO concentration, the resulting powders were named CG-0.0, CG-0.5, and CG-1.0, respectively. 3.2 Synthesis of working electrode The slurry was prepared with powders (CG-0.0, CG-0.5, and CG-1.0) as an active material, PVDF as a binder and Carbon black in (80:10:10) mass ratio. NMP was used as a solvent. Then slurry was coated on precleaned nickel foam (NF) by the doctor blade method. Then the electrodes were dried at 80 °C for 12h in oven, and the resulting electrodes were named CG-0.0, CG-0.5, and CG-1.0 respectively. These prepared electrodes were used to study supercapacitor and glucose biosensing study. 4 Nickel Oxide 4.1 Synthesis of NiO powders NiO powders with different reaction temperatures were synthesized by using the hydrothermal method followed by calcination treatment. In detail, 7.131 g of nickel chloride hexahydrate was dissolved into 60 mL DDW with constant stirring. Then 30 mL urea (2 M) was added dropwise into a nickel chloride solution. After 30 minutes of homogeneous stirring, the solution was subjected to ultrasonication for 5 minutes. Then, the solution was transferred into a Teflon-lined stainless-steel autoclave, sealed, and maintained at 1100C for 6 hours. After completion of the reaction, the resulting product was washed with DDW and ethanol several times. Then the product dried at 600C overnight. Finally, the product powder was annealed at 4000C for 2 hours. The same procedure was applied with different reaction temperatures viz 1300C, 1500C, and 1700C. The resulting powders were named P- 110, P-130, P-150, and P-170 respectively. 4.2 Preparation of working electrode Firstly, (5 cm ×1 cm) of Copper foil (CF) was mirror polished with zero grade paper, washed with a soap solution and DDW respectively, and finally air-dried. The working electrode was prepared by mixing prepared powders P-110, P -130, P-150, and P -170 as an active material, activated carbon, and PVDF as a binder in mass ratio 80:10:10 in NMP as a solvent. Then this prepared slurry coated on CF by the doctor blade method and dried at 80°C in a hot air oven overnight. The resulting electrodes were named N-110, N-130, N-150 and N-170 respectively. 5 NiO/rGO composite 5.1 Synthesis of NiO/rGO powders The NiO/rGO nanostructures by varying GO concentration were synthesized by using the hydrothermal route. In synthesis, 7.131 g of NiCl26H2O and 3.6036 g CO(NH2)2 was added in 60 mL of DDW. Different amounts of GO powder (0, 60, 120, and 180 mg) were added in 30 mL DDW in a separate beaker and ultrasonicated for 1 h. Then, these solutions were mixed and kept on constant starring for 1h. The obtained homogeneous solution was poured into a Teflon liner, sealed in autoclave and maintained at 150°C for 6 h. Afterwards, the product was cleaned with DDW and ethanol many times and dried at 60°C for 12 h. Lastly, the resulted powders annealed at 400°C for 2 h. Based on GO concentration, the resulting powders were named N1G-0, N2G-60, N3G-120, and N4G-180, respectively. 5.2 Synthesis of working electrode The CF (5 cm 1 cm) was

polished with zero grade paper, washed subsequently with soap solution and DDW several times and air dried. The actual working electrode was prepared by coating slurry on CF. The slurry was prepared with powders (N1G-0, N2G-60, N3G-120, and N4G-180) as an active material, PVDF as a binder and Carbon black in (80:10:10) mass ratio. NMP was used as a solvent. Then slurry was coated on CF by the doctor blade method. Then the electrodes were dried at 80 °C for 12h in oven, and the resulting electrodes were named N1G-0, N2G-60, N3G-120, and N4G-180, respectively. 5.3 Synthesis of solid-state supercapacitor device 5.3.1 Electrode preparation procedure The working electrode was prepared by mixing N3G-120 as an active material, Carbon black, and polyvinylidene fluoride (PVDF) as a binder in the mass ratio 80:10:10 in NMP as a solvent to form a slurry. Then this prepared slurry coated on CF by doctor blade method. The prepared electrodes heated at 80°C for 12 hours. This prepared electrode was used for electrochemical and supercapacitor study. 5.3.2 Preparation of PVA-KOH gel First In this preparation, at 353 K to get slightly viscous gel solution; in 60 ml DDW, 6 gm of PVA was dissolved. Further in another beaker in 40 ml DDW the freshly 2 M KOH is prepared and to form transparent conducting PVA-KOH gel electrolyte this solution was added dropwise into PVA gel. 5.3.3 Preparation of Symmetric Solid-State Device The large area CF is cut in area of 5×6 cm² in first step. In second step, the material was deposited by using standard Doctor blade method on area 5×5 cm² and heated at 80°C for 12 hours. The mass ratio of cathode to anode was 1:1. In next step, the prepared PVA-KOH gel was painted on prepared thin film, which was dried at room temperature for 12 h in air. To avoid any short through the sides of electrodes the sides of electrode were sealed with insulating tape. Furthermore, the two devices were merged on one another to form the SSSD by applying pressure of 1 ton. 6 Synthesis of MnO2 and MnO2/rGO composite 6.1 Synthesis of MnO2 and MnO2/rGO powders In the synthesis of MnO2 the 0.5 g of KMnO4 and 0.2 g of MnSO4 was dissolved in 50 mL DDW and stirred for 30 min. Then the resulting solution was poured in Teflon lined autoclave and maintained at 140 °C for 1 h. After completion of the reaction, the resulting product was washed with DDW and ethanol several times. Then the product dried at 60°C overnight. Similarly different MnO2/rGO powders was obtained by adding different amounts of GO powder (0, 1, 2 and 3 mg) were added in 50 mL DDW ultrasonicated for 1 h. Based on GO concentration, the resulting powders were named M-0 (Bare MnO2), M-1, M-2, and M-3, respectively. 6.2 Synthesis of working electrode The slurry was prepared with powders (M-0, M-1, M-2, and M-3) as an active material, PVDF as a binder and Carbon black in (80:10:10) mass ratio. NMP was used as a solvent. Then slurry was coated on precleaned nickel foam (NF) by the doctor blade method. Then the electrodes were dried at 80 °C for 12h in oven, and the resulting electrodes were named M1G-0, M2G-1, M3G-2, and M4G-3 respectively.

Detailed Analysis of result

1 Structural Characterizations Fig. 1 (A) demonstrates XRD pattern of prepared GO powder. The sharp peak at 12° and a secondary 43.65° peak reflects the orientation (001) and (100) for GO, respectively. Fig. 1 (B) displays FTIR of GO the peaks observed at 1062, 1212, 1393, 1623, 1723, and 3416 cm-1. The peak at 1062 and 1212 cm-1 demonstrates the C-O (alkoxy) and C-O (epoxy) stretching vibration, respectively. The 1393 cm-1 peak for the deformation of the O-H. At 1623 and 1723 cm-1, the peak reflects C=C and C=O, respectively, stretching vibrations. The results of the FTIR ratify GO's synthesis. Often used for confirming the synthesis of GO are the FT-Raman spectra (Fig. 1(C)). At 1349 and 1605 cm-1, respectively, the D and G bands of graphene were found. The UV-visible spectrum (Fig.1 (D)) indicates that the graphene oxide represents a peak at 235 nm. Fig. 1 (E) shows the FTIR spectra of Co3O4/rGO composite two sharp peaks at 561 (1) cm-1 and 662 (2) cm-1 from stretching Co-O bond vibrations, confirming the formation of Co3O4. In detail, the 1 band is characteristic of OCo3 vibrations, i.e., Co3+ in octahedral coordinate, while the 2 band is attributed to Co2+Co3+O3, i.e., Co2+ in tetrahedral coordination in the spinel structure. The characteristic peaks at 3432 cm-1 is indicated by O-H stretching vibration of the absorbed water molecule [1,2]. The peaks observed at about 1625 corresponded to the C=C. The FTIR study of NiO/rGO powders synthesized by varying GO concentrations (N1G-0, N2G-60, N3G-120, and N4G-180) is presented in Fig. 1 (F). The peaks observed at 3450 cm-1 attributed to hydroxyl groups of absorbed water [3]. The peaks observed at about 1625 and 1723 cm-1 corresponded to the C=C and C=O bonds. The peaks observed at about, 1398, 1227, and 1063 cm-1 are attributed to, C-C, C-O, and C-O-C bonds, respectively [4–6]. The absorption peaks in between 400-500 and 660 cm-1 are assigned to the stretching vibrations of Ni-O [7-9]. The fading of peak at 1723 cm-1 associated with C=O in N2G-60, N3G-120 and N4G-180 powders is due to the reduction of GO to rGO [6]. The XRD spectrum of each sample were recorded to investigate the crystal structure of synthesized NiO/rGO powders. Fig. 1 (G) presents the XRD spectra of NiO/rGO powders. The XRD diffraction peaks of N1G-0, N2G-60, N3G-120, and N4G-180 powders are corresponded with JCPDS card: 00-047-1049. The diffraction peaks of N1G-0, N2G-60, N3G-120, and N4G-180 powders at 37.06°, 43.26°, 62.78°, and 75.50° are attributed to the (111), (200), (220), and (311) crystal planes of NiO respectively. The characteristic peak of rGO at about 25° in powder N2G-60, N3G-120, and N4G-180 is not present, which may probably be because of signal converging by NiO. So, the rGO in the composite is confirmed by Raman spectra. Fig. 1 (H) illustrates the Raman spectra of different NiO/rGO composites (N1G-0, N2G-60, N3G-120, and N4G-180). The absorption peak in at around 511 cm-1 for N1G-0, N2G-60, N3G-120, and N4G-180 samples correspond to the first-order longitudinal optical (LO) mode, while the peak at 1063 cm-1 indicates 2LO phonon mode of Ni-O bond [10]. The peaks at about 1355 and 1597 cm-1 in the N2G-60, N3G-120, and N4G-180 indicate the D band (because of defected carbon layer) and G band (due to the second-order scattering of the graphitic carbon) respectively [11]. The D band of GO, N2G-60, N3G-120, and N4G-180 are at about 1350, 1317, 1355, 1352 cm-1, while the G band is at about 1609, 1568, 1597, and 1591 cm-1, respectively. The shift of the G and D band position of N2G-60, N3G-120,

and N4G-180 as compared to GO indicates the reduction of GO in NiO/rGO composites during the hydrothermal process [12]. Fig. 1 (I) shows the survey spectrum of N3G-120 powder, indicates the existence of Nickel, oxygen, and carbon elements. The observed peaks of Ni 2p, O 1s, and C 1s reveal the existence of NiO and rGO in the N3G-120 powder. In Ni 2p spectrum (Fig. 1 (J)), the main peaks observed at 854.7 as well as 872.1 eV can be assigned to the 2p3/2 and 2p1/2 spin-orbits of NiO while their corresponding satellites are present at 860.3 eV and 878.1 eV, respectively [10]. In C 1s spectrum as shown in Fig. 1 (K) the peaks at 284.1, 285.6 and 287.7 eV are related to the C=C, C-OH (epoxy/hydroxy), and O-C=O (carboxyl) respectively [13]. The peaks located at 530.9 and 528.5 eV in O 1s spectrum (Fig. 1 (L)) are related to C=O/Ni-O and O-Ni/C-O-Ni bonding configurations, respectively [12,14]. 2 Supercapacitor Study 2.1 Co3O4/rGO composite The supercapacitor study of as prepared Co3O4/rGO electrode is depicted in Fig. 2 (A-D) Fig. 2 (A) shows the comparative cyclic voltammetry (CV) study of CG-0.0, CG-0.5 and CG-1.0 electrodes. Here the CG-0.5 electrode exhibited more area under the curve as compared to other electrodes. This is because rGO in Co3O4/rGO composite offers more active sites responsible for redox reactions than bare Co3O4 and improves its conductivity. The redox reactions of OH- with remaining functional groups of rGO contribute to redox reactions in Co3O4/rGO composites. Fig. 2 (B) presents the comparative galvanostatic charge discharge (GCD) study. Here also the CG-0.5 electrode shows the better discharge time as compared to the other electrodes. This is because the rGO enhance the conductivity and provides more active sites for the redox reaction responsible for enhanced charge and discharge. The specific capacitance calculated from GCD of all Co3O4/rGO composites electrodes is shown in Fig. 2 (C). The maximum sp. capacitance calculated from GCD for CG-0.0, CG-0.5 and CG-1.0 is 304.4, 454.2 and 357.8 F g-1, respectively. Stability is one of the essential parameters in supercapacitor study. As CG-0.5 electrode shows better specific capacitance, The stability of CG-0.5 electrode was taken. Fig. 2 (D) presents the cyclic stability curve of CG-0.5 electrode. The CG-0.5 electrode exhibited outstanding cyclic stability of 90.16% over 10000 cycles. The inset of Fig. 2 (D) presents the different number of cycles of CV of cyclic stability. 2.2 NiO/rGO composite Fig. 2 (E-H) shows the supercapacitor study of NiO/rGO electrodes. The CVs of NiO/rGO electrodes (Fig. 2 (E)) are more significant as compared to bare NiO electrodes. Fig. 2 (F) shows the comparative GCD curves of N1G-0, N2G-60, N3G-120, and N4G-180 electrodes at a 1 mA cm-2 current density. From GCD curves, it is observed that the NiO/rGO composites, i.e., N2G-60, N3G-120, and N4G-180 electrodes, show better discharge time as compared to bare NiO, i.e., N1G-0 electrode. Fig. 2 (G) presents the specific capacitance of all electrodes at (1, 2, 3, 4, and 5 mA cm-2) current densities. The maximum specific capacitance calculated from GCD for N1G-0, N2G-60, N3G-120, and N4G-180 electrodes is 246.6, 384.7, 727.1, and 349.4 F g-1, respectively. Fig. 2 (H) presents the cyclic stability of the optimized N3G-120 electrode at of 7 mA cm 2 current density. The N3G-120 electrode exhibited good cyclic stability about 80.4% after 9000 cycles. The better supercapacitor performance of N3G-120 electrodes attributed to the synergistic effect of NiO and rGO where high conductivity of rGO helps to enhance the electrical conductivity of NiO/rGO composite. Such high conductivity also responsible for the better cyclic performance. 2.3 MnO2/rGO Composite Fig. 2 (I-L) depicts the supercapacitor performance of MnO2/rGO composite. Fig. 2 (I) shows the CV curves of M1G-0, M2G-1, M3G-2 and M4G-3 electrodes. Here also we observed that after addition of GO in the MnO2 the area under the curve increased. Fig. 2 (J) presents the comparative GCD curves of M1G-0, M2G-1, M3G-2 and M4G-3 electrodes. The specific capacitance of all electrodes at (0.5 to 1.75 mA cm-2) current densities is mentioned in Fig. 2 (K). The maximum specific capacitance calculated from GCD for N1G-0, N2G-60, N3G-120, and N4G-180 electrodes is 146.5, 213.7, 259.2, and 121.4 F g-1, respectively. As N3G-120 electrode showed maximum specific capacitance the cyclic stability is taken for this electrode. The N3G-120 electrode showed excellent cyclic stability of 95.7% over 10000 cycles (Fig. 2 (L)). The inset of Fig. 2 (L) presents the different number of cycles of CV of cyclic stability. 2.4 Solid state supercapacitor device (SSSD) The photographs of fabricated solid state supercapacitor device are depicted in Fig. 3 (A-B). Also, the flexibility of supercapacitor device is shown in Fig. 3 (C). The CV measurement of SSSD is carried out at the different potential windows of 0 to +1.8 V as shown in Fig. 3 (D). The sharp increase in current after +1.0 V operating potential window is suggesting the irreversible electrochemical reactions. Hence, we choose the operating potential window as a + 1.0 V for further study. Fig. 3 (E) shows the CV curves at different scan rate (10, 20, 50, 80, 100 mVs-1). Fig 3 (F) shows the GCD study of prepared SSSD at different potential windows. Fig.3 (G) shows the GCD curves at different current (3, 5, 7, 9 and 11 mA cm-2). Fig. 3 (H) shows the capacity retention vs cycle number which indicates the prepared device shows capacity retention of about 80.4% after 5000 cycles. The inset of Fig. 3 (H) shows the GCD cycles at different cycle numbers. The photograph of the actual working device with a glowing of red LED (5 mm) is shown in Fig. 3 (I). 3 Biosensing study In the glucose sensing study of different NiO/rGO composites, the same three electrode system with 0.1 M NaOH was used. Fig. 4 (A-D) presents the CVs of electrode N1G-0, N2G-60, N3G-120, and N4G-180 without glucose (blue) and with 3 mM glucose (red) at 10 mV s-1 scan rate. All electrode shows an increase in current response after the addition of 3 mM glucose. The increased current response in CV after the addition of glucose is because of electrooxidation of glucose with NiO, accompanied by oxidation from Ni2+ to Ni3+ [10]. The chronoamperometry (CA) technique is used in nonenzymatic glucose sensing to analyze glucose due to its high sensitivity [10,15–17]. Fig. 4 (E-H) shows the CA responses of N1G-0, N2G-60, N3G-120, and N4G-180 electrodes at a constant potential of +0.5 V in 0.1 M NaOH electrolyte at different concentrations of glucose (0 to 2.4 mM). It is clear that the current in the CA curve increases with increasing glucose concentration. The calibration curves of glucose concentration versus current observed for N1G-0, N2G-60, N3G-120, and N4G-180 electrodes are shown in Fig.4 (I-L), respectively. All electrode shows linearity in the range of glucose concentration 0.4 to 2.4 mM. The electrode N3G-120 exhibited the highest

442.4 A mM-1 cm-2 glucose sensitivity compared to other electrodes with R2 = 0.9964 and LOD of 7.42 M. The conductivity of rGO further improve the conducting network in NiO/rGO composites and responsible for better electron transfer kinetics. Hence NiO/rGO composite could provide more active sites for absorbing glucose and responsible for good sensitivity. Fig. 5 (A-D) shows the CA study of N1G-0, N2G-60, N3G-120, and N4G-180 electrodes obtained in the presence of glucose and relevant interfering species. The current responses of N1G-0, N2G-60, N3G-120, and N4G-180 electrodes with 1.0 mM glucose and common interferences such as 0.2 mM of Fructose (FR), Ascorbic acid (AA), NaCl, and KCl are shown in Fig. 5 (E-H) respectively. The N3G-120 electrode, as compared to the other electrodes, shows the minimum change in response towards glucose even in the presence of interfering species. Fig. 5 (I) shows the CV curves of CG-0.5 electrode in absence of glucose (black) and in presence of 0.5 mM glucose (red). The CV curves in the presence of 0.5 mM glucose at different scan rates are mentioned in Fig. 5 (J). The CA response of CG-0.5 electrode at a constant potential of +0.5 V in 0.1 M NaOH electrolyte at different concentrations of glucose (0 to 0.5 mM) (Fig. 5 (K)). It is clear that the current in the CA curve increases with increasing glucose concentration. The calibration curves of glucose concentration versus current observed for CG-0.5 electrode is shown in Fig. 5 (L). The CG-0.5 electrode shows 5.8324 mA mM-1 cm-2 of glucose sensitivity with R2 = 0.9827. References 1. Makhlouf, S.A., Bakr, Z.H., Aly, K.I., and Moustafa, M.S. (2013) Structural, electrical and optical properties of Co3O 4 nanoparticles. Superlattices Microstruct., 64, 107-117. 2. Patel, V.K., Saurav, J.R., Gangopadhyay, K., Gangopadhyay, S., and Bhattacharya, S. 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Zhou, G., Wang, D.W., Yin, L.C., Li, N., Li, F., and Cheng, H.M. (2012) Oxygen bridges between nio nanosheets and graphene for improvement of lithium storage. ACS Nano, 6 (4), 3214-3223. 15. Khoshroo, A., Sadrjavadi, K., Taran, M., and Fattahi, A. (2020) Electrochemical system designed on a copper tape platform as a nonenzymatic glucose sensor. Sensors Actuators B Chem., 325, 128778. 16. C, Z., MM, T., and X, L. (2013) A microfluidic paper-based electrochemical biosensor array for multiplexed detection of metabolic biomarkers. Sci. Technol. Adv. Mater., 14 (5). 17. Lopa, N.S., Rahman, M.M., Ahmed, F., Sutradhar, S.C., Ryu, T., and Kim, W. (2018) A Ni-based redox-active metal-organic framework for sensitive and non-enzymatic detection of glucose. J. Electroanal. Chem., 822, 43-49.











Conclusions

The hydrothermally synthesized Co3O4/rGO composite shows highest specific capacitance of 454.2 F g-1 at 1 mA cm-2. The prepared supercapacitor electrode exhibited excellent cyclic stability of 90.16% over 10000 cycles. In case of non-enzymatic glucoses sensing the electrode achieved 5.8324 mA mM-1 cm-2 glucose sensitivity. In case of hydrothermally synthesized NiO/rGO, the different NiO/rGO composites was obtained by varying GO concentration. The highest specific capacitance of 727.1 F g-1 at 1 mA cm-2 applied current density was achieved by NiO/rGO composite. Also, it exhibited good cyclic stability of about 80.4% after 9000 cycles. The symmetric solid state supercapacitor device prepared by using optimized NiO/rGO composite can showed excellent cyclic stability of 80.4% over 5000 cycles and can glow red LED. In the case of nonenzymatic glucose sensing, the optimized NiO/rGO composite exhibited the maximum 442.4 A mM-1 cm-2 glucose sensitivity compared to other electrodes with R2 = 0.9964 and LOD of 7.42 M. The MnO2/rGO composite showed maximum specific capacitance of 259.2 F g-1 at a current density of 0.5 mA cm-2. The optimized electrode reported an extraordinary cyclic stability of 95.7% over 10000 cycles. The overall study reveals that all the prepared composite electrodes show excellent electrochemical supercapacitor as well as nonenzymatic glucose biosensing properties.

Scope of future work

In future work the effect of not only electron irradiation but also ion beam irradiation on the supercapacitor as well as nonenzymatic glucose biosensing will be studied. Ternary metal oxides are promising candidates in the supercapacitor field due to their favorable synergistic effect arising from multicomponent metal ions and high electrical conductivity. Hence, such ternary metal oxides and their graphene-based composite for energy storage is an interesting study. Also, This work lead to supercapacitor device fabrication and possible to give industry for commercial use.

List of Publications (only from SCI indexed journals) :

Title of the Paper	List of Authors	Journal Details	Month & Year	Volume	Status	DOI No	Imp Fac
Review on recent progress in hydrothermally synthesized MCoO/rGO composite for energy storage devices	O. C. Pore, A. V. Fulari, R. V. Shejwal, V. J. Fulari, G. M. Lohar.	CHEMICAL ENGINEERING JOURNAL (International)	Dec- 2021	426 (131544)	Publishe d	https: //doi. org/10. 1016/j.cej. 2021.1315 44	13.
Hydrothermally synthesized CoO microflakes for supercapacitor and non- enzymatic glucose sensor	O. C. Pore, A. V. Fulari, R. K. Kamble, A. S. Shelake, N. B. Velhal, V. J. Fulari, G. M. Lohar	Journal of Materials Science: Materials in Electronics (International)	Jul- 2021	32 (20742)	Publishe d	https: //doi. org/10. 1007/s108 54-021- 06586-y	2.4
High stability Mn2O3/MnCO3 microcubes synthesized by hydrothermal method for supercapacitor application	O.C.Pore, A.V.Fulari, S. H.Mujawarc, R.V. Shejwal, V.J.Fulari, G. M.Lohar	MATERIALS SCIENCE IN SEMICONDUCT OR PROCESSING (International)	Feb- 2022	143 (106550)	Publishe d	10.1016/j. mssp. 2022.1065 50	3.92
Hydrothermally synthesized urchinlike NiO nanostructures for supercapacitor and nonenzymatic glucose biosensing application	O. C. Pore, A. V. Fulari, N. B. Velhal, V. G. Parale, H. H. Park, R. V. Shejwal, V. J. Fulari, G. M. Lohar	MATERIALS SCIENCE IN SEMICONDUCT OR PROCESSING (International)	Nov- 2021	134 (105980)	Publishe d	https: //doi. org/10. 1016/j. mssp. 2021.1059 80	3.9

List of Papers Published in Conference Proceedings, Popular Journals :

Title of the Paper	List of Authors	Journal Details	Month & Year	Volume	Status	DOI No	Imp Fac
Not Available							

List of Patents filed/ to be filed :

Patent Title	Authors	Patent Type	Country/Agency Name	Patent Status	Applicatior nt No.
Not Available					

Equipment Details :

Equipment Name	Cost (INR)	Procured	Make & Model	Utilization %	Amount Spent (INR)	Date of Procurement
Vacuum furnace	1,49,624	Yes	Ants ceramics	100	1,49,624	27 Jun, 202
Double distilled water plant	58,646	Yes	glass double distalation unit	100	58,646	03 Dec, 202
Weight balance (0.1 mg)	80,984	Yes	CAI-234 contech	99.96	80,948	03 Nov, 20
Ultrasonic Sonicator (Probe sonicator)	1,02,542	Yes	PS500-LED	100	1,02,542	03 Sep, 202
Hydrothermal unit with high pressure autoclave	99,592	Yes	hydrothermal unit	100	99,592	03 Jun, 202

Plans for utilizing the equipment facilities in future:

The equipment's sanctioned by DST-SERB will be utilized for following work which is currently in progress

1. Synthesis and characterization of nickel molybdate reduced graphene oxide-based composites for supercapacitor applications.

- 2. Development of NiCo2O4 base nanostructures for hydrothermal method for supercapacitor application.
- 3. Synthesis and Characterization of NiCo2S4/rGO Composite for Supercapacitor.
- 4. Chemically synthesized M Co2O4/rGO (M= Mn, Zn, Ni) based nanostructures for supercapacitor application.
- 5. Chemically synthesized vanadium doped nickel hydroxide thin films for supercapacitor application.