

Project Completion Report (2017-2020)

Of

**Collaborative Research Project under
Indo-Hungarian Strategic Research Fund (IHSRF) of Department of Science and
Technology of India and National Research, Development and Innovation Office
(NRDIO) of Hungary.**

**Title of the Project: Biochemicals and biofuels from lignocellulosic biomass
by Green catalytic processes.**

Collaborative Institutions

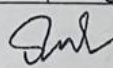
From Indian Side

Department of Energy
Tezpur University (A Central University under Govt. of India)
Tezpur-784028, Assam, INDIA

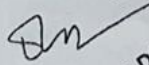
From Hungary Side:

Institute of Materials and Environmental Chemistry
Research Centre for Natural Sciences
Hungarian Academy of Sciences
H-1117 Budapest, Magyar Tudósokkörútja 2.

1.	DST reference No.	INT/HUN/P-02/2016 dtd. 23-02-2017	
2.	Project title	Biochemicals and biofuels from lignocellulosic biomass by Green catalytic processes.	
3.	Objectives	<p>i. To investigate hydroconversion of biomass-derived platform molecules, such as levulinic acid (LA) to gamma-valerolactone (GVL) and 2-methyl tetrahydrofuran (2-MTHF) over oxide-supported transition metal catalysts in order to provide cheaper catalytic systems which we will prove to have comparable performance with respect to noble metal based ones.</p> <p>ii. To obtain a renewable multipurpose heterogeneous catalyst that is active, versatile, and stable under the process conditions which can compete with currently employed commercial catalysts for biomass conversion to biofuels and chemicals with maximum product yield.</p> <p>iii. To examine the synergic effect of oxide-supported transition metal catalysts and biobased renewable catalyst for biomass conversion to biofuels and chemicals.</p> <p>iv) To understand and study the catalytic reaction mechanism of above catalysts.</p>	
4.	Field of S&T covered under the project	Broad Area Green Chemistry (including catalysis) Sub-Area Catalytic transformation of lignocellulosic biomass to fuel and chemical.	
5.	Project participants		
	Indian side	Foreign side	
	Dr.Dhanapati Deka Professor and Former Head, Department of Energy, Tezpur University Naapam, Tezpur-784028 Assam, INDIA	Dr.Valyon József Institute of Materials and Environmental Chemistry Research Centre for Natural Sciences Hungarian Academy of Sciences H-1117 Budapest, Magyar Tudósokörútja 2	
6.	Date of start of the project	The project was sanctioned by DST, India on 23-02-2017	
	Date of completion	22.02.2020	
7.	Visits undertaken (please include the number and duration of respective visits)		
		Name & Address of the visiting scientist	Duration of the visit
	India to Hungary	Professor Dhanapati Deka, PI and Professor, Department of Energy, Tezpur University, Tezpur-784028, Assam and Dr. Utpal Bora, Co-PI, Department of Chemical Sciences, Tezpur University, Tezpur-784028, Assam	June 12-20, 2017
	Hungary to India	Dr. Robert Barthos, Scientist and Mr. Gyula Novodarszki, PhD student from the Green Chemistry Research Group, IMEC, RCNS, HAS, Budapest, Hungary	November 22-30, 2017


Prof. Dhanapati Deka
 Principal Investigator
 Department of Energy
 Tezpur University
 Assam, India

- **Equipment & computational facilities:** Equipment and computational facilities were adequate in the working place for the project works in Department of Energy, Tezpur University and Institute of Materials and Environmental Chemistry, Research Centre for Natural Sciences, Hungarian Academy of Sciences, Budapest. As per project provision, fund was not allocated for purchase of any equipment.
- **Exchange of Data/Samples:** Samples of Renewable heterogeneous catalysts prepared in Tezpur University were handed over to Hungarian Scientists during their visit to Tezpur University (November 22-30,2017) under project provision frame work to test and characterize the samples in Hungarian laboratories. Data generated during experimental works of the project were exchanged for paper publication and further progress of the projects by both countries.
- **Exposure to advanced technologies:** Exposure to different types of high grade analytical instruments available in partner institution at Hungary such as Rigaku R-AXIS RAPID image plate diffractometer, Differential Scanning Calorimeter (DSC), Varian NMR System(R), 600 MHz, Varian NMR System(R), 400 MHz, X-ray photoelectron spectroscopy – sum-frequency spectroscopy (XPS – SFG), pyrolysis gas chromatography – mass spectrometry (Py-GC/MS), Thermogravimetry/mass spectrometry (TG/MS) etc. Visited to different laboratories of the partner institution at Hungary and exposed to their ongoing advanced research works such as *Biomass utilization via olefin metathesis*- this research project focuses on the metathesis of algae phospholipids produced as a side product during the synthesis of high-value algae oil, *Development of hydrogen storage systems Biopolymer synthesis*- catalyst systems are investigated upon effective participation under these conditions in aqueous media even under mild conditions, *Levulinic acid and γ -valerolactone*, it has been demonstrated that levulinic acid can be obtained with high yield by chemical conversion of the sugar polymer cellulose and hemicellulose, components of lignocelluloses etc.
- **Opportunity for new interactions with any other research Organizations:** Visited to different laboratories of the partner institution at Hungary and its nearby laboratories and exposed to their ongoing advanced research works such as *Biomass utilization via olefin metathesis*-this research project focuses on the metathesis of algae phospholipids produced as a side product during the synthesis of high-value algae oil, *Development of hydrogen storage systems Biopolymer synthesis*- catalyst systems are investigated upon effective participation under these conditions in aqueous media even under mild conditions, *Levulinic acid and γ -valerolactone*, it has been demonstrated that levulinic acid can be obtained with high yield by chemical conversion of the sugar polymer cellulose and hemicellulose, components of lignocelluloses, *Synthesis of molecularly imprinted polymers* -an innovative TT protection technique using biodegradable MIPs made by olefin metathesis, etc.
- **Participation in Conferences:**
 - i) Daimary, N. Gohain, M. and Deka, D. Heterogeneous catalyst synthesis from Acer laurinum Hasskarl oil cake waste: Application on Mesua ferrea oil and Acer laurinum Hasskarl. Presented in International Conference on Emerging Trends in Chemical Sciences 26-28 February, 2018 Department of Chemistry, Dibrugarh University.
 - ii) Mihályi M. R., Novodárszki Gy., Deka D., Thakur A. J. and Valyon J.: Hydrodeoxygenation of levulinic acid, γ -valerolactone, 1,4-pentanediol, and 2-methyltetrahydrofuran over supported Co catalyst. Presentation on the "FP1306 COST Action Fourth Workshop & Fifth MC Meeting, Thessaloniki, 12-14 March 2018".
 - iii) Mihályi M. R., Novodárszki G., Deka D., Thakur A. J., F. Lónyi, and J. Valyon: Steering the catalytic conversion of levulinic acid ether to γ -valerolactone or to 2-methyltetrahydrofuran using silica supported cobalt catalyst. FP1306 COST Action Third Workshop & Fourth MC Meeting, Torremolinos, 27-28 March 2017.
 - iv) Deka D.: Delivered a lecture on "Renewable heterogenous catalyst for biofuel production" as visiting scientist in Institute of Materials and Environmental Chemistry,


 Prof. Dhanapati Deka
 Principal Investigator
 Department of Energy
 Tezpur University
 Tezpur - A

Annexure-1

Accomplishment Status : (vis-à-vis the project objectives and milestones, highlighting the major/salient achievements):

Project Title: "Biochemicals and biofuels from lignocellulosic biomass by Green catalytic processes". (Department of Energy, Tezpur University and Institute of Materials and Environmental Chemistry Research Centre for Natural Sciences, Hungarian Academy of Sciences were the two collaborating Institutions from India and Hungary, respectively).

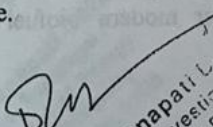
Lignocellulosic biomass is an environmentally benign substitute for fossil carbon sources in the production of fuel, chemicals and carbon-based products. The field of heterogeneous catalysis has immense potential to help convert such renewable feedstocks into fuels and chemicals.

Hungarian partner studied the consecutive hydrogenation and dehydration reactions of levulinic acid to high value-added molecules, such as cyclic compound γ -valerolactone (GVL) and 2-methyl tetrahydrofuran (2-MTHF) employing noble metal catalysts. Co and Ni catalysts loaded on typical well-ordered micro- and mesoporous supports for acetic acid reduction was also carried out by Hungarian counterpart. Instead of expensive noble metal catalysts, they used cheaper oxide-supported transition metal catalysts. Silica and alumina supported transition metal catalysts were prepared by wet impregnation. Silica-supported Ni catalyst was employed against heterogeneous hydroconversion of levulinic acid. Silica-supported cobalt catalysts was also employed against hydroconversion of levulinic acid to γ -valerolactone or 2-methyltetrahydrofuran. By understanding the catalytic LA reaction network, they (Hungarian part) developed catalysts of well-balanced hydrogenation dehydration activity for LA conversion to high value-added products.

Indian partner developed multifunctional mesoporous solid acids prepared by the sulfonation of chemically activated carbonized waste biomass or waste de-oiled seedwaste cake (DOWC), a solid waste from biodiesel production. 4-Benzenediazoniumsulfonate (4-BDS) was used as sulfonating agent. Thus, renewable heterogeneous Catalysts were prepared and employed against the conversion of lignocellulosic biomass to Platform chemical and biofuel. Carbon based SO_3H -C Heterogeneous Catalyst was prepared by Hydrothermal Process. The developed SO_3H -C catalyst was used to produce levulinic acid and Ethyl Levulinate from Levulinic acid in presence of ethanol.

Within the framework of the project, exchange visit from India to Hungary and Hungary to India were accomplished during 2017-18. Visiting scientists from both the countries took part in common seminar followed by project progress discussion and laboratory exposure during the period of visit.

Due to COVID-19 pandemic, no further visit was made from both the countries. Project was completed on 22-02-2020 without receiving any third installment from the funding Agency for Indian side.


Prof. Dhanapati Le
Principal Investigator
Department of Energy
Tezpur University
Tezpur, Assam

8. Yearly Project milestones

Date of Sanction of the project : 23.02.2017

2017-18

1. Skype meeting with project partners of both the countries, discussion on project and strategy formulation to achieve the project objectives.
2. Exchange visit of Scientists and Students of both the participating institutions
3. Synthesis of Heterogeneous Catalyst –Indian Partner
4. Catalytic micro and mesoporous supports for acetic acid reduction at Hungary
5. Guerbet self-coupling for Ethanol valorization –Hungarian Partner.

2018-19

1. Catalyst synthesis and characterization – Indian Partner.
2. Application of prepared catalyst for conversion of lignocellulosic biomass to soluble sugars- Indian Partner.
3. Study the Hydrodeoxygenation of levulinic acid, GVL, 1,4-pentanediol, and 2-methyltetrahydrofuran over supported Co catalyst- Hungarian Partner.

2019-20

1. Synthesis of Carbon based SO₃H-C Functionalized Heterogeneous Catalyst by Hydrothermal Process- Indian Partner.
2. Study the consecutive hydrogenation and dehydration reactions of levulinic acid for conversion to high value-added molecules, such as cyclic compound γ -valerolactone (GVL), 2-methyl tetrahydrofuran (2-MTHF) and pentanoic acid (PA)—Hungarian Partner.
3. Both homogeneous and heterogeneous metal catalysts, particularly noble metal catalysts such as Ru, Pt and Pd have been applied for LA transformation _Hungarian Partner.
4. Synthesis of multifunctional mesoporous solid acids and employed against the conversion of lignocellulosic biomass to Platform chemical and biofuel- Indian Partner.

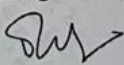
9. Progress of the Project:

Accomplishment Status : (vis-à-vis the project objectives and milestones, highlighting the major/salient achievements): (Up-to 1 page)	Please see Annexure-1
List of joint research publications (Please attach copies)	Please see Annexure-2
Technology/ New Processes/ Patents generated	Bio-based catalyst activity in lignocellulosic biomass conversion. No patent generated.
Scope for commercializing the new Scientific Knowledge	Industrial application in bio-based industry/biorefinery is possible with the process generated.

10. Please elaborate with your remarks on the collaboration:

Specific advantages derived:

- **Expertise:** Trained two JRFs from Indian Side with the technology and processes for conversion of lignocellulosic biomass, employing renewable heterogeneous catalysts.


Prof. Dhanapati Deka
 Principal Investigator
 Department of Energy
 Tezpur University
 Tezpur, Assam, India

Annexure-2

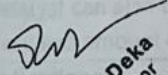
List of joint research publications (Please attach copies)

(A). Papers published in cited (SCI)

1. Novodárszki, G., Valyon, J., Illés, Á., Dóbe, S., Deka, D., Hancsók, J. and Mihályi, M.R. Heterogeneous hydroconversion of levulinic acid over silica-supported Ni catalyst. *Reaction Kinetics, Mechanisms and Catalysis*, 126 (2), 795-810 (2019).
2. Novodárszki, G., Solt, H.E., Valyon, J., Lónyi, F., Hancsók, J., Deka, D., Tuba, R. and Mihályi, M.R. Selective hydroconversion of levulinic acid to γ -valerolactone or 2-methyltetrahydrofuran over silica-supported cobalt catalysts. *Catalysis Science and Technology*, 9 (9), 2291-2304 (2019).
3. Onyestyák G., Novodárszki G., Wellisch FÁ, Kalló D, Thakur AJ, Deka D: Co and Ni catalysts loaded on typical well-ordered micro- and mesoporous supports for acetic acid reduction. *Reaction Kinetics Mechanisms And Catalysis* 121: pp. 109-119 (2017)
4. Onyestyák G., Novodárszki G., Wellisch FÁ, Valyon J, Thakur AJ, Deka D: Guerbet self-coupling for ethanol valorization over activated carbon supported catalysts. *Reaction Kinetics Mechanisms And Catalysis* 121: pp. 31-41. (2017).
5. Novodárszki G., Onyestyák G., Barthos R., Wellisch FÁ, Thakur AJ, Deka D, Valyon J: Guerbet alkylation of acetone by ethanol and reduction of product alkylate to alkane over tandem nickel/Mg, Al-hydrotalcite and nickel molybdate/ γ -alumina catalyst systems. *Reaction Kinetics Mechanisms And Catalysis* 121: pp. 69-81. (2017).

(B) Papers published in Conference Proceedings, Popular Journals etc.

1. Mihályi M. R., Novodárszki Gy., Deka D., Thakur A. J. and Valyon J.: Hydrodeoxygenation of levulinic acid, γ -valerolactone, 1,4-pentanediol, and 2-methyltetrahydrofuran over supported Co catalyst. Presentation on the "FP1306 COST Action Fourth Workshop & Fifth MC Meeting, Thessaloniki, 12-14 March 2018"
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5. Novodárszki G., Mihályi M. R., Deka D., Bora U., Valyon J.: Heterogeneous catalytic hydroconversion of γ -Valerolactone. Presentation on the „13th Pannonian International Symposium on Catalysis, 19-23 September 2016, Siófok, Hungary”.
6. Novodárszki Gy., Mihályi M. R., Deka D., Onyestyák Gy., Valyon J.: Biomasszábólnyerhető platform vegyületek heterogén katalitikus átalakítása. Presentation on the "XXII. Nemzetközi Vegyészkonferencia, 2016. November 3-6., Temesvár, Romania" (in Hungarian).


Prof. Dhanapati Deka
Principal Investigator
Department of Energy
Tezpur University
Tezpur, Assam, India

- Research Centre for Natural Sciences, Hungarian Academy of Sciences, Budapest 1117 on 16-06-2017 in a common seminar organized by Hungary Counterpart.
- v) Mihályi M. R., Novodárszki G., Valyon J. and Deka D.: Levulinic acid hydroconversion over oxide-supported Co catalysts. Presentation on the „13th Pannonian International Symposium on Catalysis, 19-23 September 2016, Siófok, Hungary”.
 - vi) Onyestyák G., Novodárszki G., Thakur A. J., Deka D.: Guerbet alkylation for biomass valorization. Presentation on the „13th Pannonian International Symposium on Catalysis, 19-23 September 2016, Siófok, Hungary”.
 - vii) Novodárszki G., Mihályi M. R., Deka D., Bora U., Valyon J.: Heterogeneous catalytic hydroconversion of γ -Valerolactone. Presentation on the „13th Pannonian International Symposium on Catalysis, 19-23 September 2016, Siófok, Hungary”.

11. Application potential (immediate/long term)-

Long Term : Industrial application in bio-based industry/biorefinery of the process of using renewable catalyst in production of biofuel and chemicals from lignocellulosic biomass.
Immediate :Chemical laboratory for replacing inorganic catalyst in various chemical reactions by bio-based renewable/heterogeneous catalyst.

12. Financial details of the project-

Total project cost	Rs. 34,42,600/-
Money received	Rs. 20,02,845/-
Expenditure incurred	Rs. 16,77,204/-*
Final SE/UC (in prescribed format attached)	Yes.

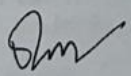
* Unspent amount of Rs.325641 has been sent through Bharatkosh.gov.in receipt no. 0405220008602 dtd. May 5, 2022 along with Rs. 15001 as interest earned (transaction no. 0405220011066 dtd. May 5, 2022).

13. Conclusion summarizing the achievements and indication of scope for future work-

It was a fruitful collaboration between Tezpur University, India and Institute of Materials and Environmental Chemistry, RCNS, HAS, Budapest, Hungary. Though, COVID-19 pandemic has hampered the research collaboration, both the countries did result oriented research based on defined objectives. Scientists from both the countries were participated in exchange visits for scientific discussion, presentation and formulated strategies for implementation of the project. Indian partner synthesized multifunctional mesoporous bio-based solid heterogenous catalysts and employed against the conversion of lignocellulosic biomass to Platform chemical and biofuel. Hungarian partner conducted hydrogenation and dehydration reactions of levulinic acid for conversion to high value-added molecules, such as cyclic compound γ -valerolactone (GVL), 2-methyl tetrahydrofuran (2-MTHF) and pentanoic acid (PA). They also carried out application of homogeneous and heterogeneous noble metal catalysts for LA transformation. Besides, Hungarian partner studied the hydrodeoxygenation of levulinic acid, GVL, 1,4-pentanediol, and 2-methyltetrahydrofuran over supported Co catalyst.

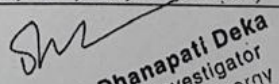
Future works:

Lignocellulosic biomass is an environmentally benign substitute for fossil carbon sources in the production of fuel, chemicals and carbon-based products. For effective conversion with optimal conditions, extensive study on bio-based acid and base heterogeneous catalyst production, catalysts modification, kinetic study can be undertaken for modern biofuel and chemical production.

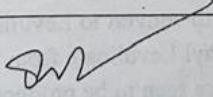

Prof. Dhanapati Deka
 Principal Investigator
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 Tezpur University
 Tezpur.

Department of Science & Technology
Impact Analysis

Title of the project: Biochemicals and biofuels from lignocellulosic biomass by Green catalytic processes.	
Indian PI: Dr. Dhanapati Deka Institute: Department of Energy, Tezpur University City: Tezpur, Assam, India, PIN-784028 E-mail: dhanapati@tezu.ernet.in	Foreign PI: Dr. Valyon József Institute: Institute of Materials and Environmental Chemistry, Research Centre for Natural Sciences, Hungarian Academy of Sciences. City: H-1117 Budapest, Magyar Tudósokkörútja 2 E-mail: valyon.jozsef@ttk.mta.hu
Total Expenditure in Rs. 16,77,204/- vs Total sanctioned cost Rs. 20,02,845/- Cost on Indian side	Total Expenditure in US \$ vs Total sanctioned cost: Not applicable.
HR Trained: Two JRF trained Indian side	HR Trained: Not applicable Partner side
Exchange visits undertaken: India to Partner: 02 Nos. Partner to India: 02 Nos. Professor Dhanapati Deka and Dr. Utpal Bora, Tezpur University, India to Hungary. Dr. Robert Barthos, Scientist and Mr. Gyula Novodarszki, PhD student from the Green Chemistry Research Group, IMEC, RCNS, HAS, Budapest, Hungary to India.	
Outcome in Brief: Indian Side: synthesized multifunctional mesoporous bio-based solid heterogeneous catalysts and employed against the conversion of lignocellulosic biomass to Platform chemical and biofuel. Hungarian Partner: conducted hydrogenation and dehydration reactions of levulinic acid for conversion to high value-added molecules, such as cyclic compound γ -valerolactone (GVL), 2-methyl tetrahydrofuran (2-MTHF) and pentanoic acid (PA). They also carried out application of homogeneous and heterogeneous noble metal catalysts for LA transformation. Besides, Hungarian partner studied the hydrodeoxygenation of levulinic acid, GVL, 1,4-pentanediol, and 2-methyltetrahydrofuran over supported Co catalyst.	
Significant Breakthrough: 1. Developed catalyst HC-SO ₃ H has a potential to convert cellulose present in lignocellulose to levulinic acid as well as glucose. 2. More than 85% Levulinic acid yield is observed at 78% conversion of Cellulose. 3. Very Less amount of sugar (glucose) remains to convert to Levulinic acid. 4. Catalyst can also be used for production of Ethyl Levulinate from Levulinic acid. 5. Very less amount of by-products (eg: water) are seen to be produced during the reaction	
Joint Publications:	
List of Joint Publications from this Project in SCI (title, author(s), journal, year)	IF
1. Novodárszki, G., Valyon, J., Illés, Á., Dóbbé, S., Deka, D., Hancsók,	


Prof. Dhanapati Deka
Principal Investigator
Department of Energy
Tezpur University

J.andMihályi, M.R. Heterogeneous hydroconversion of levulinic acid over silica-supported Ni catalyst. <i>Reaction Kinetics, Mechanisms and Catalysis</i> , 126 (2), 795-810 (2019).	2.081
2. Novodárszki, G, Solt, H.E, Valyon, J, Lónyi, F, Hancsók, J, Deka, D , Tuba, R. and Mihályi, M.R. Selective hydroconversion of levulinic acid to γ -valerolactone or 2-methyltetrahydrofuran over silica-supported cobalt catalysts. <i>Catalysis Science and Technology</i> , 9 (9), 2291-2304 (2019).	6.119
3. Onyestyák G, Novodárszki G, Wellisch FÁ, Kalló D, Thakur AJ, Deka D : Co and Ni catalysts loaded on typical well-ordered micro- and mesoporous supports for acetic acid reduction. <i>Reaction Kinetics, Mechanisms And Catalysis</i> 121: pp. 109-119 (2017)	2.081
4. Onyestyák G, Novodárszki G, Wellisch FÁ, Valyon J, Thakur AJ, Deka D : Guerbet self-coupling for ethanol valorization over activated carbon supported catalysts. <i>Reaction Kinetics Mechanisms And Catalysis</i> 121: pp. 31-41. (2017).	2.081
5. Novodárszki G, Onyestyák G, Barthos R, Wellisch FÁ, Thakur AJ, Deka D , Valyon J: Guerbet alkylation of acetone by ethanol and reduction of product alkylate to alkane over tandem nickel/Mg,Al-hydrotalcite and nickel molybdate/ γ -alumina catalyst systems. <i>Reaction Kinetics Mechanisms And Catalysis</i> 121: pp. 69-81. (2017).	2.081
Patent: Nil	
Technology Readiness Level (TRL) of the Outcome: (1 to 10 scale): TRL level 3-4	
Social Readiness Level (SRL) of the Outcome: (1 to 10 scale): Impact to Society SRL 1 -3	
Benefit of the collaboration on research work: (If joint collaboration not happened) The project was undertaken on Joint collaboration of Tezpur University, India and Institute of Materials and Environmental Chemistry, RCNS, HAS, Budapest, Hungary.	
Overall Outcome in common man language : Lignocellulosic biomass is an environmentally benign substitute for fossil carbon sources in the production of fuel, chemicals and carbon-based products. During this research collaboration, Indian and Hungarian partner were engaged with mutual exchange of research findings and exchange of scientists for the benefit of both the groups. Indian partner synthesized multifunctional mesoporous bio-based solid heterogenous catalysts and employed against the conversion of lignocellulosic biomass to platform chemical and biofuel. Hungarian partner conducted hydrogenation and dehydration reactions of levulinic acid for conversion to high value-added molecules, such as cyclic compound γ -valerolactone (GVL), 2-methyl tetrahydrofuran (2-MTHF) and pentanoic acid (PA). They also carried out application of homogeneous and heterogeneous noble metal catalysts for LA transformation. Besides, Hungarian partner studied the hydrodeoxygenation of levulinic acid, GVL, 1,4-pentanediol, and 2-methyltetrahydrofuran over supported Co catalyst. The result and methodologies were exchanged among participation partners for further studies.	

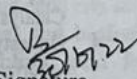

Prof. Dhanapati Deka
 Principal Investigator
 Department of Energy
 Tezpur University
 Tezpur, Assam, India

ACHIEVEMENT-CUM-PERFORMANCE REPORT

This institution was sanctioned one programme of 1095 days in the subject of **Green Chemistry** during the year 2017-2020. A grant of Rs 20,02,845/- (Rupees twenty lakh two thousand eight hundred forty five) only was sanctioned and releases by Ministry of Science and Technology, Government of India through Demand Draft No. **Electronic Transfer**, Drawn on Bank of **State Bank of India, Tezpur University** (Bank account no. 30448821505) vide letter no INT/HUN/P-07/2016 dtd. 23-02.2017 and 07.05.2019. Out of the advance, an amount of Rs. 16,77,204/- (Rupees Sixteen lakh seventy seven thousand two hundred four) has been utilized the purpose for which it was sanctioned leaving a balance of Rs 325641/- (Rupees three lakh twenty five thousand six hundred forty one) only which was sent through Bharatkosh.gov.in receipt no. 0405220008602 dtd. May 5, 2022 along with Rs. 15001/- as interest earned (transaction no. 0405220011066 dtd. May 5, 2022). Proper procedure was followed as per the prescribed guidelines in making payments.

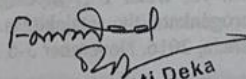
Outcome of the programme in terms of achievement-cum-performance are:

Indian partner synthesized multifunctional mesoporous bio-based solid heterogenous catalysts and employed against the conversion of lignocellulosic biomass to Platform chemical and biofuel. Hungarian partner conducted hydrogenation and dehydration reactions of levulinic acid for conversion to high value-added molecules, such as cyclic compound γ -valerolactone (GVL), 2-methyl tetrahydrofuran (2-MTHF) and pentanoic acid (PA). They also carried out application of homogeneous and heterogeneous noble metal catalysts for LA transformation. Besides, Hungarian partner studied the hydrodeoxygenation of levulinic acid, GVL, 1,4-pentanediol, and 2-methyltetrahydrofuran over supported Co catalyst. Scientists from both the countries were participated in exchange visits for scientific discussion, presentation and formulated strategies for implementation of the project.


Signature

(Head of the Institution)

Registrar
Tezpur University
Napaam, Tezpur


Prof. Dhanapati Deka
Principal Investigator
Department of Energy
Tezpur University
Tezpur, Assam, India

FORM GFR 12 A

UC ID: 18250779

FORM GFR 12-A
[See Rule 238(1)]

Form of Utilization Certificate FOR AUTONOMOUS BODIES OF THE GRANTEE ORGANIZATION

UTILIZATION CERTIFICATE FOR THE YEAR 2021-2022 in respect
of Recurring/non-recurring
GRANTS-IN-AID/SALARIES/CREATION OF CAPITAL ASSETS

1. Name of the Scheme : **RESEARCH AND DEVELOPMENT(s&t)-3237**

2. Whether recurring, pr non-recurring grants : N/A

3. Grants positions of the beginning of the Financial year :

- (i.) Cash in Hand/Bank : 0.00
- (ii.) Unadjusted advances : 0.00
- (iii.) Total : 0.00

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

Grant-in-aid-General	Grant-in-aid-Salary	Grant-in-aid-creation of capital assets	Total
0.00	0.00	325641.00	325641.00
		DST/INT/HUN/P-07/2016	09-05-2019
			325641.00
			0.00
			0.00
			0.00

Grant-in-aid-General	Grant-in-aid-Salary	Grant-in-aid-creation of capital assets	Total
0.00	0.00	0.00	0.00

Details of grants position of the end of the year

3. Grants positions of the End of the Financial year :

- (i.) Cash in Hand/Bank : 0.00
- (ii.) Unadjusted advances : 0.00
- (iii.) Total : 0.00

Certified that I have satisfied myself that the condition on which the grants-in-aid was sanctioned have been duly fulfilled/are being fulfilled and that I have exercised the following checks to see that the money was actually utilised for the purpose for which it was sanctioned.

1. 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.

2. 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 internal controls is exercised to ensure their effectiveness.

3. 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.

4. The responsibilities among the key functionaries for execution of the schema have been assigned in clear terms and are not general in nature.

5. The benefits were extended to the intended beneficiaries and only such areas/districts were guidelines and terms and conditions of the grants-in-aid.

6. It has been ensured that the physical and financial performance under RESEARCH AND DEVELOPMENT(s&t)-3237 (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

FORM GFR 12 A

UC ID: 18249358

FORM GFR 12-A
[See Rule 238(1)]

Form of Utilization Certificate FOR AUTONOMOUS BODIES OF THE GRANTEE ORGANIZATION

UTILIZATION CERTIFICATE FOR THE YEAR 2020-2021 in respect
of Recurring/non-recurring
GRANTS-IN-AID/SALARIES/CREATION OF CAPITAL ASSETS

1. Name of the Scheme : **RESEARCH AND DEVELOPMENT(s&t)-3237**

2. Whether recurring pr. non-recurring grants : N/A

3. Grants positions of the beginning of the Financial year

(i.) Cash in Hand/Bank : 0.00

(ii.) Unadjusted advances : 0.00

(iii.) Total: 0.00

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

0.00	0.00	0.00	DST/INT/HUN/P-07/2016	09-05-2019	425198.00	425198.00	99557.00	325641.00
Grant-in-aid-General			Grant-in-aid-Salary		Grant-in-aid-creation of capital assets			Total
99557.00			0.00		0.00			99557.00

Details of grants position of the end of the year

3. Grants positions of the End of the Financial year :

(i.) Cash in Hand/Bank : 325641.00

(ii.) Unadjusted advances : 0.00

(iii.) Total : 325641.00

Certified that I have satisfied myself that the condition on which the grants-in-aid was sanctioned have been duly fulfilled/are being fulfilled and that I have exercised the following checks to see that the money was actually utilised for the purpose for which it was sanctioned.

- 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.
- 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 internal controls is exercised to ensure their effectiveness.
- 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.
- The responsibilities among the key functionaries for execution of the schema have been assigned in clear terms and are not general in nature.
- The benefits were extended to the intended beneficiaries and only such areas/districts were guidelines and terms and conditions of the grants-in-aid
- It has been ensured that the physical and financial performance under RESEARCH AND DEVELOPMENT(s&t)-3237 (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

FORM GFR 19

UC ID: 18250779

FORM GFR 19-A
 [See Rule 212(1)]
Form of Utilization Certificate

Sl. No.	Sanctioned by Ministry	Date	Forwarded Amount
1	DST/INT/HUN/P-07/2016	09-05-2019	325641.00

Certified that Out Of Rs. Nil Grants-in-aid Sanctioned during the year 2021-2022 in Favour Of **Tezpur University** under this Ministry/Department Letter No. given in the margin and Rs.325641.00 on account of unspent balance of the previous year, a sum of Rs. 0.00 has been utilized for the purpose of for which it was sanctioned and that the balance of Rs 325641.0000 remaining unutilized at the end of year has been surrendered to Government (vide No Transaction Ref. No.0405220008602 Dated. dated)/ will be adjusted towards the grants-in-aid payable during the next year 2022-2023 Interest earned is 0.00 and Additional expenditure of Rs 0.00 has been incurred from internal resources and will be adjusted against next release.

2. Certified that I have satisfied myself that the condition on which the grants-in-aid was sanctioned have been duly fulfilled/are being fulfilled and that I have exercised the following checks to see that the money was actually utilised for the purpose for which it was sanctioned.

Kinds Of checks exercised

- Cash book verified regularly
- Bank Pass Book verified
- Stock Register verified
- Chartered Accountant checked the expenses and certified
- Ledger
- Payment vouchers
- Bank Reconciliation
- Inventory
- Vouchers

Signature.....
 Designation.....
Finance Officer
 Date.....
Tezpur. University
 14/5/22

FORM GFR 12 A

UC ID: 18249315

FORM GFR 12-A
[See Rule 238(1)]

Form of Utilization Certificate FOR AUTONOMOUS BODIES OF THE GRANTEE ORGANIZATION

UTILIZATION CERTIFICATE FOR THE YEAR 2019-2020 in respect of Recurring/non-recurring GRANTS-IN-AID/SALARIES/CREATION OF CAPITAL ASSETS

1. Name of the Scheme : **RESEARCH AND DEVELOPMENT(s&t)-3237**

2. Whether recurring pr non-recurring grants :N/A

3. Grants positions of the beginning of the Financial year :

- (i.) Cash in Hand/Bank : -13162.00
- (ii.) Unadjusted advances . 13162.00
- (iii.) Total: 0.00

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

0.00	0.00	0.00	DST/INT/HUN/P-07/2016	09-05-2019	757845.00	757845.00	332647.00	425198.00
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Grant-in-aid-General	Grant-in-aid-Salary	Grant-in-aid-creation of capital assets	Total
332647.00	0.00	0.00	332647.00

Details of grants position of the end of the year

3. Grants positions of the End of the Financial year :

- (i.) Cash in Hand/Bank : 0.00
- (ii.) Unadjusted advances : 425198.00
- (iii.) Total : 425198.00

Certified that I have satisfied myself that the condition on which the grants-in-aid was sanctioned have been duly fulfilled/are being fulfilled and that I have exercised the following checks to see that the money was actually utilised for the purpose for which it was sanctioned.

1. 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/accouns.
2. There exist internal controls for safeguarding public funds/assets , watching outcomes and achivevemnets of physical targets against the financial inputs,ensuring quality in asset creation etc. & the periodic evaluation internal controls is exercised to ensure their effectiveness.
3. 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.
4. The responsibilites among the key functionaries for execution of the schema have been assigned in clear terms and are not general in nature.
5. The benefits were extended to the intended beneficiaries and only such areas/districts were guidelines and terms and conditios of the gaints-in-aid.
6. It has been ensured that the physical and financial performance under RESEARCH AND DEVELOPMENT(s&t)-3237 (name of the scheme has been according to the requirements . as proscribed in the guidclines issued by Govt. of india and the performane/targets achieved statement for the year to which the utilization of the fund resulted in outcomes given

at Annexure- I duly enclosed.

7. The utilization of the fund resulted in outcomes given at Annexure -2 duly enclosed(to be formulated by the Ministry/Department concerned as per their requirements/specifications.)

8. Details of various schemes executed by the agency through grants-in-aid received from the some Ministry or from other Ministries is enclosed at Annexure-2 (to be formulated by the Ministry/Departments concerned as per their requirements/specifications).

Date :

Place :

Signature

Name.....

Chief Finance Officer
(Head of the Finance)

Signature

Name.....

Head of the Organisation

6/14/22
Finance Officer
Tezpur University

(Strike out in inapplicable terms)
Registrar
Tezpur University
Napaam, Tezpur

FORM GFR 12 A

UC ID: 18249357

FORM GFR 12-A
[See Rule 238(1)]

Form of Utilization Certificate FOR AUTONOMOUS BODIES OF THE GRANTEE ORGANIZATION

UTILIZATION CERTIFICATE FOR THE YEAR 2019-2020 in respect
of Recurring/non-recurring
GRANTS-IN-AID/SALARIES/CREATION OF CAPITAL ASSETS

1. Name of the Scheme : **INTERNATIONAL COOPERATION S & T-1012**

2. Whether recurring pr non-recurring grants : N/A

3. Grants positions of the beginning of the Financial year .

- (i.) Cash in Hand/Bank : **0.00**
- (ii.) Unadjusted advances : **0.00**
- (iii.) Total: **0.00**

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

0.00	0.00	0.00	INT/HUN/P-07/2016	23-02-2017	13162.00	13162.00	13162.00	0.00
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Grant-in-aid-General	Grant-in-aid-Salary	Grant-in-aid-creation of capital assets	Total
13162.00	0.00	0.00	13162.00

Details of grants position of the end of the year

3. Grants positions of the End of the Financial year :

- (i.) Cash in Hand/Bank : **0.00**
- (ii.) Unadjusted advances : **0.00**
- (iii.) Total : **0.00**

Certified that I have satisfied myself that the condition on which the grants-in-aid was sanctioned have been duly fulfilled/are being fulfilled and that I have exercised the following checks to see that the money was actually utilised for the purpose for which it was sanctioned.

1. 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.
2. There exist internal controls for safeguarding public funds/assets , watching outcomes and achivevemnets of physical targets against the financial inputs,ensuring quality in asset creation etc. & the periodic evaluation internal controls is exercised to ensure their effectiveness.
3. 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.
4. The responsibilites among the key functionaries for execution of the schema have been assigned in clear terms and are not general in nature.
5. The benefits were extended to the intended beneficiaries and only such areas/districts were guidelines and terms and conditios of the gaints-in-aid.
6. It has been ensured that the physical and financial performance under INTERNATIONAL COOPERATION S & T-1012 (name of the scheme has

at Annexure- 1 duly enclosed.

7. The utilization of the fund resulted in outcomes given at Annexure -2 duly enclosed (to be formulated by the Ministry/Department concerned as per their requirements/specifications.)

8. Details of various schemes executed by the agency through grants-in-aid received from the some Ministry or from other Ministries is enclosed at Annexure-2 (to be formulated by the Ministry/Departments concerned as per their requirements/specifications).

Date :

Place :

Signature

Name.....

Chief Finance Officer
(Head of the Finance)

Signature
Finance Officer
Tezpur University

Signature

Name.....

Head of the Organisation

(Strike out in inapplicable terms)

Registrar
Tezpur University
Napaam, Tezpur

**Final Statement of Expenditure
Indo- Hungary project on "Biochemicals and Biofuels From Lignocellulosic Biomass by Green Catalytic Processes"**

Sl No.	Sanctioned Heads	Funds Allocated (indicated Sanctioned) (III)	1 st installment Grant Released Date: 23.02.2016	2 nd installment Grant released Date: 07.05.2019	Expenditure Incurred						Total expenditure IV+V+VI (VII)	Balance as on 31-03-2021 (VIII)	Remarks (if any)
					1 st installment Expenditure	2016-17	2017-18	2018-19	2019-20	2020-21			
1.	Manpower Cost	10,29,600/-	3,30,000/-		Nil	1,94,355/-	3,00,000/-	199,194/-	25000/-	7,18,549/-		No grant was received as 3 rd installment. Moreover, due to COVID-19 outbreak, no exchange visit was taken.	
2.	Consumables	13,50,000/-	4,50,000/-		24,990/-	2,92,719/-	Nil	24980/-	74557/-	4,17,246/-			
3.	Contingencies	1,50,000/-	50,000/-		6,584/-	43,324/-	Nil	48600/-	Nil	98,508/-			
4.	Exchange Visit (Indian)	3,76,000/-	1,88,000/-		Nil	1,75,455/-	Nil	Nil	Nil	1,75,455/-			
5.	Exchange Visit (Hungarian Scientist)	2,88,000/-	1,44,000/-		Nil	95,643/-	Nil	Nil	Nil	95,643/-			
6.	Overhead expenses @ 10 %	2,49,000/-	83,000/-		90,775/-	Nil	7993/-	73035/-	Nil	1,71,803/-			
Grand Total		34,42,600/-	12,45,000/-	7,57,845/-	1,22,349/-	8,01,496/-	3,07,993/-	3,45,809/-	99,557/-	16,77,204/-	3,25,641/-		

Prof. Dhanapati Deka

Name and Signature of Principal Investigator

Date: **Prof. Dhanapati Deka**

Principal Investigator
Department of Energy

Tezpur University

Signature of Competent financial authority

Date: **(With seal) Finance Officer**

Tezpur University

*DOS - Date of Start of project: 23.02.2016, Interest on Bank: Rs 395.00 (2019-20) + Rs.8151.00 (2020-21) + Rs. 6455.00 (April,2021 till February,2022)

Total interest earned = 395+8151+6455=15,001.00.

Total amount to be refunded = Rs. 3,25,641.00 + Rs. 15,001.00 = Rs. 3,40,642.00.

- Expenditure under the sanctioned heads, at any point of time, should not exceed funds allocated under that head, without prior approval of DST 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 next financial year.