INDIAN INSTITUTE OF TECHNOLOGY DELHI

HAUZ KHAS, NEW DELHI – 110016

IITD/BCHE (SP-4805)/2024

Invitation for

Expression of Interest (EoI)

For

Manufacture and Supply of Solid Catalyst for a Pilot Plant Facility

1. Indian Institute of Technology Delhi (IITD) invites online Expression of Interest (EoI) from catalyst manufacturers (the 'Applicants'), who can manufacture ~150 kg catalyst for a pilot plant facility, based on the catalyst synthesis recipe provided by IITD.
2. The details of submission requirements, scope of work, eligibility and evaluation criteria, etc. can be downloaded from the Central Public Procurement Portal at www.eprocure.gov.in
3. The EoI is to be submitted online on Central Public Procurement Portal (http://eprocure.gov.in/eprocure/app). Last date of submission of EoI is **05.12.2024 by 5:00 PM**.
4. A meeting to provide further information is being conducted in a hybrid mode. The Applicants are encouraged to attend in person. The following are the details of the venue and timings:
   Venue: Chemical Engineering Department Seminar Room (Block II, Room 278)
   Timings: **11 AM, Nov 18, 2024**
   The applicants can also attend the meeting online at the following link:
   Meeting link
5. Further details/clarifications, if any, may be obtained from Dr. Divesh Bhatia, Department of Chemical Engineering, Indian Institute of Technology Delhi, Hauz Khas, New Delhi - 110016 (Email: dbhatia@chemical.iitd.ac.in, Tel : +91 11 2659 1456).

Date: 13/11/2024

A. Introduction

A catalyst has been developed at the laboratory scale by IIT Delhi (IITD). It is now proposed to qualify suppliers who can synthesize the pelletized catalyst at 1 kg scale and further scaleup the synthesis to make ~150 kg pelletized catalyst. The synthesized catalysts will be subjected to performance, morphological, chemical, and mechanical testing to meet the specifications set forth by IITD. IITD invites Expression of Interest (EoI) from catalyst manufacturers (the 'Applicants'), who are interested in performing the catalyst synthesis scaleup and provide the catalyst to IITD as per the scope of work specified in Section C below.

B. Selection Process

A two-stage process will be followed for selection of the 'Supplier' for supply of the catalyst. In the 1st stage, the Applicants shall submit the Expression of Interest (EoI). The format of submission of EoI is given in Section F. For those Applicants who meet the eligibility criteria specified in Section G, the evaluation of EoIs will be carried out by the purchase finalization committee (PFC), based on the evaluation criteria specified in Section H. Based on this evaluation, a list of qualified Applicants shall be prepared using the procedure outlined in Section I.

In the 2nd stage, the request for Proposals (RFP) will be invited from only the qualified Applicants. The Proposals submitted by the qualified Applicants will consist of the technical and financial bids, which will be ranked. Based on this ranking, the "Supplier" will be determined.

C. Scope of work

1. The base recipe of the catalyst will be provided by IITD to the Supplier after signing a non-disclosure agreement (NDA), as given in Annexure I. The Supplier will use the provided recipe and their expertise to scale up the synthesis of the catalyst to produce 1 kg catalyst within 4 months, and thereafter will produce ~150 kg catalyst within 3 months. The catalyst must be manufactured by the Supplier and not be outsourced to a third-party vendor. The detailed workflow containing the responsibilities of the Supplier and the procedure of exchange of materials and information is given in Section D.

2. The scaled-up catalyst must meet the performance metrics set forth by IITD, the details of which are given in Table 1. The performance testing at the gram scale will be done by the Supplier, and the performance testing of the pelletized catalyst will be done at a pilot plant by IITD. The Supplier will also perform quality checks by measuring the chemical, morphological and mechanical attributes, the details of which are given in Table 2. The Supplier will perform the required testing for quality measures using their own facilities or outsource it. In either case, the responsibility of testing lies with the Supplier.

3. The Supplier is encouraged to suggest additional quality measures that may be relevant for ensuring that the catalyst meets the industry standards. These measures should be finalized after sharing of the catalyst recipe by IITD but before the start of the first synthesis activity by the Supplier.

Table 1. Performance evaluation measures

S. No.	Inlet temperature (°C)	Reactor pressure (bar)	Mass of catalyst (g)	Volumetric Rate (sccm)	Performance attribute	Measured value at gram scale	Acceptable deviation from measured value
1	240	40	1	40	CO_2 conversion, methanol yield and selectivity	To be provided by IITD	±2%
2	260	40	1	40	CO_2 conversion, methanol yield and selectivity	To be provided by IITD	±2%
3	240	60	1	40	CO_2 conversion, methanol yield and selectivity	To be provided by IITD	±2%
4	260	60	1	40	CO_2 conversion, methanol yield and selectivity	To be provided by IITD	±2%
5	240	40	1	80	CO_2 conversion, methanol yield and selectivity	To be provided by IITD	±2%
6	260	60	1	80	CO_2 conversion, methanol yield and selectivity	To be provided by IITD	±2%

Table 2. Chemical, morphological, and mechanical attributes of catalysts

S. No.	Property	Measurement technique (if any)	Acceptable value OR deviation from lab-scale measurement
Chemical attributes (to be satisfied by powder and pellet)			
1	Composition (wt.%)	ICP	± 1% of lab-scale measurement
2	Metal dispersion (%)	CO chemisorption	± 1% of lab-scale measurement
3	Crystal formation	XRD	Same as lab-scale
Morphological attributes (to be satisfied by powder and pellet)			
1	BET surface area (m^2/g)	BET analyzer (N_2 physisorption)	± 2% of lab-scale measurement
2	Pore volume (cm^3/g)	BJH method	± 2% of lab-scale measurement
Mechanical attributes (for pellet only)			
1	Shape and size	Vernier callipers	Cylindrical pellets (6 mm ± 0.5 mm x

2	Average crush strength	Industry standard	200 ± 30 Nm
3	Shipping density	Industry standard	1100 ± 100 kg/m^3

D. Detailed workflow (technical)

1. The base recipe of the catalyst will be provided by IITD to the Supplier after signing of the non-disclosure agreement (NDA) given in Annexure I.

2. The scaleup of catalyst production to obtain ~150 kg catalyst will be performed in four stages, as given in Table 3. In stage 1, the Supplier will make the powder catalyst at the gram scale using the exact procedure given by IITD. Further, the scaleup to achieve the pellet form of the catalyst would be done by the Supplier in two more stages: from 1 gram scale to 100 g scale, and then from 100 g scale to 1 kg scale. If the performance measures provided in Table 1 are met, the Supplier will scaleup the production further to produce ~150 kg catalyst.

3. At each stage of the scaleup, the Supplier will optimize the catalyst synthesis procedure using the base recipe provided by IITD and the Supplier's prior expertise in catalyst synthesis scaleup. It may require multiple iterations from the Supplier to arrive at the optimum procedures and operating conditions for various steps of catalyst synthesis.

4. At each stage, the Supplier will perform performance testing of the catalyst using the crushed form of the final catalyst pellets in a lab-scale reactor. Once the Supplier confirms that the performance measures provided in Table 1 are met, the catalyst will be sent to IITD. IITD will conduct an independent performance evaluation of the catalyst and benchmark the results against the expected performance. IITD can get more independent performance evaluation tests of this catalyst sample at partner institutions, labs, or third-party vendors.

5. At each stage, the Supplier will measure the morphological, chemical, and mechanical properties of the catalyst provided in Table 2, and provide the data to IITD. IITD will also conduct independent measurements for these quality attributes at IIT laboratories or at partner institutions, labs, or third-party vendors.

6. At each stage, once IITD confirms that the required attributes are achieved, IITD will inform the Supplier to scaleup the catalyst synthesis to the next stage.

7. At each stage, if there are deviations between the reported attributes by the Supplier and those measured by IITD or its partners, IITD and the Supplier will setup joint meetings to find the likely cause and propose solutions to address the deviations.

Table 3. Stages of catalyst scaleup

Stage Number	Activity
1	Synthesis of ~1-5 grams catalyst
2	Synthesis of ~100-200 grams catalyst
3	Synthesis of 1 kg catalyst
4	Synthesis of ~150 kg catalyst

E. Catalyst synthesis procedure

The broad catalyst synthesis procedure is provided below. The exact procedure and the materials to be used will be shared only with the selected Supplier after signing of the NDA. The typical procedures outlined in this section can be used by the Applicant in evaluating their readiness levels to undertake a catalyst scaleup assignment.

Procedure 1: A series of $M1_x$-$M2_y$ – $M3_z$ mixed metal oxides catalysts are synthesized by varying M1/M2/M3 molar ratios. Typically, appropriate amounts of nitrate (aq) solutions of these metals are dissolved in deionized water (500-600 mL), followed by the addition of NH_4OH (aq) until the pH reaches ~ 9. After 30 min of vigorous stirring, the slurry is transformed into a Teflon-lined hydrothermal synthesis autoclave, lasting for 24 h under 160 °C- 200°C. When the autoclave cools down to room temperature, the solid is separated by a high-speed centrifuge first, and then washed with deionized water as well as ethanol one after another 3 times. Finally, the mixed metal oxide samples are dried under 80 °C for 12 -16 h and calcined in static air under 500 °C at very slow heating rate for 2 – 3 hrs. The powder catalyst is then pelletized for use in a pilot scale reactor.

Procedure 2: In a typical preparation, appropriate amounts of nitrate (aq.) solutions of these metals are dissolved in deionized water (500-600 mL), followed by the addition of NH_4OH (aq.) until the pH reaches ~ 9. After stirring for 1 h, followed by ultrasonication for 2 hours, the resulting slurry is aged for 2 h. Thereafter, the solid is separated by filtration first and then washed with deionized water and ethanol. Finally, the mixed metal oxide samples are dried under 80 °C for 12 -16 h and calcined in static air under 500 °C at very slow heating rate for 2 – 3 hrs. The powder catalyst is then pelletized for use in a pilot scale reactor.

F. Format for Expression of Interest

The following is the format for submission of EoI. Supporting documents (wherever applicable) should be attached.

1. Details of the Firm a. Name	

b. Legal Status : Individual / Proprietorship / Partnership / Private Limited Company / Public Limited Company / Other c. Registered Address d. Date of establishment e. Contact Person, Designation, and Contact Details	
2. Brief Profile of the Firm	
3. Past experience of the Firm a. Number of years of business in India b. Existing catalyst production capacity c. Amount of catalyst manufactured in the past three financial years (Apr '21 – Mar '24)	
4. Infrastructure and Manpower a. Existing catalyst manufacturing equipment / machinery b. Number of employed manpower at production plant c. List of characterization equipment (BET, XRD, ICP, particle size distribution measurement, CO chemisorption, any other)	
5. Quality Norms a. Quality Certifications (if any) b. Quality check procedures	
6. Financial Strength of the Firm a. Turnover for the last three financial years (Apr '21 – Mar '24) b. Net profit for the last three financial years (Apr '21 – Mar '24)	

7. Past catalyst scaleup projects (Individual details of at least three projects to be provided with a minimum of one project for mixed metal oxide catalysts)

Title	**Description**		
Client Name and Address			
Client Reference*	Name and Designation:	Phone No.:	Email ID:
Project Scope (in brief)			
Type of catalyst produced (zeolite / supported metal or metal oxide / any other)			
Catalyst quantity produced (in kg)			
Order Amount (INR)			
Status of the project (Ongoing / completed)			

*The PFC member(s) may contact the clients to get feedback on the Applicant

8. If selected as the Supplier, does the Applicant agrees to sign the NDA document in its present form (Annexure I)? If not, changes to the NDA document should be suggested.

9. Does the Bidder have the resources and capability to provide 1 kg catalyst and thereafter ~150 kg catalyst which meets the specifications? If there are infrastructure requirements to build the capacity to produce the desired catalyst amount, these should be mentioned here.

G. Eligibility criteria

This section lists the minimum eligibility criteria for consideration of the EoI. If the criteria specified in this section is met, the EoI will be further evaluated as per the evaluation criteria specified in Section H.

Table 3. Eligibility criteria

S. No.	Criteria	Required Documentation
1	Only manufacturers of the catalysts are eligible. Applicants who intend to outsource the catalyst production work to other third-party vendors are NOT eligible.	Document stating the Applicant to be a manufacturer
2	The Applicant should have the necessary equipment / infrastructure / machinery for manufacture of 1 kg catalyst and ~150 kg catalyst. List of equipment include but not limited to autoclaves, slurry mixers, air/vacuum drying ovens, calciner, high pressure pelletizer, and ball mill. Optional equipment include centrifuge and ultrasonicator.	List of equipment / infrastructure / machinery as per Annexure II
3	The Applicant should have the experience of scaling up the production of at least two different powder catalysts to make a minimum of 100 kg catalyst pellets	Provide information on past catalyst scaleup projects as per Table in S. No. 7 of Section F. Copy of work order / contract / client's testimonials to be attached.
4	Average annual turnover should be at least 5 crores in any of the three years of the last five financial years (Apr '19 – Mar '24)	Balance sheet

H. Criteria for evaluation

For the Applications which meet the minimum eligibility criteria given in Section G, the EoI shall be evaluated based on the following parameters:

1. Availability of appropriate equipment / infrastructure / machinery for manufacture of 1 kg and ~150 kg catalyst (20 marks)
2. Prior experience of scaling up catalyst production from powder to pellet (20 marks)
3. Catalyst production capacity of existing plants (15 marks)
4. Availability of in-house characterization facilities (15 marks)
5. Availability of lab-scale reactor for catalyst evaluation at upto 60 bar (10 marks)
6. Quality norms followed at the existing plant and/or any quality certifications (10 marks)

7. Prior experience of working with academic institutions (10 marks)

   The Purchase Finalization Committee (PFC) will invite the Applicant to make a presentation on their company profile, infrastructure, past projects, and other relevant information relevant to catalyst scaleup. The PFC member (s) may also make a visit to the Applicant's manufacturing plant, characterization facilities, and laboratories.

I. Shortlisting of qualified Applicants: Points will be allotted to each Applicant based on the parameters specified in Section H. Only those Applicants who get a score of 70 marks or more out of 100 shall be declared as qualified for the invitation of 'Request for Proposals (RFP)'. If the number of such qualified Applicants is less than two, the PFC may, in its sole discretion, qualify the Applicant(s) whose score is less than 70 marks; provided that in such an event, the total number of qualified Applicants shall not exceed two.

J. Finalization of the Supplier: 'Request for Proposals' will be invited only from the qualified Applicants in response to a set of terms and conditions of the procurement. The Proposals submitted by the qualified Applicants will consist of the technical and financial bids. The Proposals will be evaluated and ranked. Based on this ranking, the "Supplier" will be determined.

K. Signing of non-disclosure agreement (NDA)
The Supplier will need to sign a non-disclosure agreement (NDA) with IITD. The NDA document is given in Annexure I.

Annexure I. Non-Disclosure Agreement (NDA)

This Non-Disclosure Agreement (Agreement) is by and between the Indian Institute of Technology Delhi (hereinafter referred to as IITD) having its address at Hauz Khas, New Delhi-110016 through Prof. Sreedevi U., and ……(hereinafter referred to as Supplier), a company having a business address…….., on this ……..being the date when this Agreement comes into force.

Recitals

<Supplier> is engaged in scaleup and production of catalysts at the bulk scale;

IITD has, through its team of researchers, successfully developed a catalyst at the laboratory scale and wishes that it should be scaled up by the Supplier to produce 1 kg catalyst and thereafter ~150 kg catalyst, herein referred to as the "Purpose"

<Supplier> and IITD (through Prof. Sreedevi U.), referred to as the Parties, now wish to enter into this Agreement to scale up catalyst production from 1 g scale to ~150 kg scale.

A. IITD (through Prof. Sreedevi U.) and Supplier wish to exchange information for the sole purpose of scaling up the catalyst production for a Pilot Plant Facility (hereinafter referred to as Information) and each party regards the information shared to be confidential and desires to protect it from unauthorised disclosure or use.

B. IITD (through Prof. Sreedevi U.) as Disclosing Party is willing to disclose information to Supplier as Receiving Party on the terms and conditions set forth herein

WHEREBY it is agreed as follows:

1. **Definition of Confidential Information**

For purposes of this NDA, "Confidential Information" includes any and all information, data, documents, and materials related to the catalyst synthesis process. This includes but is not limited to the information, data, documents, and materials provided by IIT Delhi to the Supplier, whether in oral, written and machine-readable form, or any other form. “Confidential Information” also includes the information, data, documents, and materials generated during the scaleup activities by the Supplier or its partners, wherein the scaleup activities include but not limited to morphological, chemical, and mechanical characterization of the catalyst, and performance evaluation of the catalyst.

2. **Terms and conditions**

The Supplier shall

- Maintain the confidentiality of the Confidential Information and will use it solely for the purpose of scaling up the catalyst synthesis.
- Not disclose Confidential Information to any other person or party without prior written consent from IITD.
- Not reverse engineer the Confidential Information provided to the Supplier;
- Restrict disclosure of the Confidential Information solely to those employees of the Supplier who have the need to know the Confidential Information in order to accomplish the Purpose.
- Inform and advise each such employee, before he or she receives access to the Information of the obligations of the Supplier under this Agreement and require each such employee to maintain those obligations

3. **Return and Destruction of Confidential Information**

Within fifteen (15) days of notice furnished by IITD or upon termination of this NDA, the Supplier shall return all documentation, copies, notes, diagrams, prototypes and other materials containing any portion of Confidential Information, and then destroy all such materials containing the Confidential Information. The complete transfer of Confidential Information followed by destruction should be certified by the Supplier.

4. **Term**

The term of this agreement shall be 3 years from the date hereof or the date of termination of the MoU guiding this NDA, whichever is earlier. The obligation of this agreement shall continue for a period of 5 years after the disclosure has been made. However, the Supplier’s obligations of confidentiality and restriction on use of the Confidential Information disclosed by IITD shall survive termination of this agreement.

5. License and IP

The Supplier acknowledges and agrees that the Confidential Information shall remain the sole property of IITD. Neither the execution of this agreement nor the furnishing of the Confidential Information hereunder shall be construed as granting either expressly or by implication, any license under or title to any invention, patent, copyright, trademark or trade name now or hereafter owned by or controlled by IITD. IITD will be sole owner of any IP generated during the catalyst scaleup process.

6. Other terms

IITD does not make any representation with respect to and does not warrant any information provided under this agreement, but shall furnish such in good faith. Without restricting the generality of the foregoing, IITD does not make any representations or warranties, whether written or oral, statutory, express or implied with respect to the information which may be provided hereunder, including without limitation, any warranty of merchantability or of fitness for a particular purpose. IITD shall not be liable for any special, incidental or consequential damages of any nature whatsoever resulting from receipt or use of the information by the Supplier.

The rights and obligations of IITD and the Supplier under this Agreement may not be sold, assigned or otherwise transferred.

7. Governing Law

This agreement will be construed and governed in accordance with the laws of India. Any dispute arising out or in connection with the Agreement shall be settled within the jurisdiction of New Delhi courts.

8. Signatures

IN WITNESS WHEREOF, the parties have executed this agreement effective as of the date first written above.

For and on behalf of Indian Institute of Technology Delhi Signature: _____ Name: Title: Date: _____	**For and on behalf of <Supplier>** Signature: _____ Name: Title: Date: _____
Witness 1: **Name:**	**Witness 2:** **Name:**

Annexure II. Availability of equipment / infrastructure / machinery for catalyst scaleup

The following are the details of the equipment / infrastructure / machinery required for manufacturing ~150 kg catalyst.

S. No.	Name of equipment / infrastructure / machinery	Purpose	Available at premises (Yes/No)? If No, what is the proposed plan, e.g., procurement / using third-party facility / renting for use at own facility / any other)
1			
2			
3			
4			
5			