

TERMS OF REFERENCE FOR THE R&D PROJECT

1 Title of the Project

Study on Pyrolysis Oil for Determination of Correlation Amongst Feedstock Composition, Manufacturing Technology, and Performance Characteristic

2 Background

Pyrolysis oil is a synthetic fuel, derived from tyres, biomass, and plastics, which can act as a substitute for fossil derived fuels. Depending on its quality, pyrolysis oils can be used as fuel for industrial burners, residential heaters, commercial boilers, automotive engines, and marine applications.

NITI Aayog and NGT, as part of Circular Economy (CE) Action Plans, have propagated pyrolysis oil industry. This product is being manufactured as well as imported in India.

However, the end application of pyrolysis oil is a cause of major concern. As it is derived from waste tyres/end of life tyres, biomass, or waste plastic, there is small to minimal control on the quality and composition of feedstock. This leads to presence of undesirable elements such as metals, chlorides, sulphur, silica, water, to name a few, in the fuel which can have deleterious effects when used in industries and engines.

While manufacturers and importers are claiming excellent performance properties of pyrolysis oil, there is no Indian Standard on the product to validate these claims. There is one International Standard ASTM D7544, however it is limited to biomass as feedstock.

Hence, it is important that a thorough analysis of feed composition, manufacturing process, and pyrolysis oil quality is carried out for pyrolysis oil being manufactured and imported in India. Data gathered from such analysis will help in establishing correlation amongst feedstock composition, manufacturing process, and product quality; and based on the product quality, the end use application can be determined. This correlation and pyrolysis oil quality data will provide much needed empirical evidence to BIS.

3 Objective

To collect technical data and scientific evidence with respect to feedstock composition, manufacturing process, and performance characteristics of pyrolysis oil and establish correlation

4 Scope

- 4.1** Extensive and thorough examination of the available literature on pyrolysis oil, including but not restricted to the following and provide comparative analysis:
 - a) International standards;
 - b) Research papers;
 - c) Guidelines by ministry/regulatory bodies;
 - d) Any studies being conducted by any organization; and
 - e) Any other sources.
- 4.2** Identification of manufacturing base of pyrolysis oil in India along with categorization of large, medium, small and micro units. Collection of information on feedstock composition, manufacturing process, and product quality and analysis of information.
- 4.3** Identification of exporters and importers of pyrolysis oil in India. Collection of information on product quality and technical regulations/standards followed for export.
- 4.4** Determination of testing infrastructure available in India for pyrolysis oil, characteristics being tested and test methods being followed.
- 4.5** Visit to the manufacturing units of pyrolysis oil ensuring that minimum two units for each of the three different feedstocks – tyres, biomass, and plastics – is visited. Collection of pyrolysis oil samples and preparation of comprehensive industry visit report.
- 4.6** Identification of user base of pyrolysis oil and collection of feedback on intended application, product quality, and performance satisfaction.
- 4.7** Testing of collected pyrolysis oil samples from NABL accredited laboratory and submission of analytical report establishing a correlation amongst feedstock composition, manufacturing process, and pyrolysis oil characteristics.

5 Research Methodology

- 5.1** Undertake thorough literature review as per **4.1** and prepare summary report including comparative analysis;
- 5.2** Identify manufacturing base categorized into large, medium, small, and micro. Contact the manufacturers and collect information using a structured questionnaire; suggested format given in **Annexure I**. Inform them about requirement of industry visit and collection of pyrolysis oil samples.
- 5.3** Identify exporters and importers of pyrolysis oil. Contact them and collect information using a structured questionnaire, suggested format given in **Annexure II**. Inform them about requirement of collection of pyrolysis oil samples.
- 5.4** Undertake visit to identified manufacturing units, considering criteria set in **4.5** and the following activities shall be carried out and report prepared:
 - 5.4.1** Observation on
 - a) Feedstock being used and its composition;
 - b) Manufacturing process being utilized;

- c) Grades or varieties of the product being manufactured;
- d) In-process quality control;
- e) Characteristics being tested for the final product and test methods being used;
- f) Marking and labelling; and
- g) Packaging practices.

5.4.2 Discussion with relevant person of industry regarding

- a) Changes in feedstock and process and how it leads to different grades of pyrolysis oil;
- b) Sustainability practices being implemented;
- c) Buyers/users of the pyrolysis oil manufactured at their unit; and
- d) Collection of samples for all varieties of pyrolysis oil manufactured in the unit.

5.5 Identify users of pyrolysis oil. Contact the users and collect information using a structured questionnaire, suggested format given in **Annexure III**.

5.6 Identify laboratories for testing of pyrolysis oil. Conduct visits to the laboratories, observe characteristics being tested and test methods being followed. Preferably one government laboratory and one NABL accredited private laboratory should be covered in the visits. Explore NABL accredited laboratories where complete testing of pyrolysis oil samples for characteristics identified in **Annexure IV** can be carried out.

5.7 Coordinate testing of the collected pyrolysis oil samples for the characteristics identified in **Annexure IV** using the recommended test methods. If the manufacturer has claimed any additional properties, the same should also be tested as per the test method declared by the manufacturer. Test report for each sample shall have complete information on source of the sample (manufacturer/importer), feedstock composition, manufacturing process, reported values, and test method used.

5.8 Based on the test reports and information collected through questionnaires, visits and discussion, analyze and establish correlation amongst feedstock composition, manufacturing process, and pyrolysis oil characteristics and submit project report.

6 Deliverables

6.1 Project report, in hard copy and digital formats, covering all aspects mentioned in scope

6.2 Questionnaires, discussion and visit reports, test reports, to be appended with the project report

7 Timeline and Method of Progress Review

7.1 Timeline for the project is 4 months from the date of award of the project.

7.2 Stages for Review:

7.2.1 Stage I: At the end of 1st month, project allottee shall prepare a comprehensive plan identifying the following:

- a) Details of literature review carried out and summarized report;
- b) Identified manufacturers, exporters, importers, laboratories, and users;

- c) Information obtained through questionnaires from the above-mentioned stakeholders and visits to be carried out;
- d) Laboratory where testing is to be carried out; and
- e) Test method proposed to be used for characteristics listed in Annexure IV and any additional characteristics, associated sample volume and sampling plan.

Member Secretary will evaluate the plan and provide feedback, if any.

7.2.2 Stage II – At the end of 3rd month, project allottee to submit draft report with the following information:

- a) Reports of visits carried out to manufacturing units and laboratories;
- b) Details of feedstock composition and manufacturing processes being used;
- c) Number of samples collected with information related to source of the sample (manufacturer/importer), feedstock composition, and manufacturing process;
- d) Test reports; and
- e) Analysis of data and correlation amongst feedstock composition, manufacturing process, and pyrolysis oil characteristics

Sectional Committee will evaluate the draft report and provide feedback/recommend changes, if required. In 2 weeks, project allottee to submit final project report incorporating recommendations/feedback of Committee.

8 Support from BIS

BIS will provide access to latest available editions of Indian standards and/ or international standards relevant to the project, on request.

9 Nodal Officer

Ms. Kreeti Das, Sc. C/Deputy Director, PCD, BIS, may be contacted at pcd3@bis.gov.in for any queries on the research project.

Annexure I

Suggested Questionnaire for Pyrolysis Oil Manufacturers

Name of Industry	
Location	
Contact Details	
Details of Pyrolysis Oil Manufactured <ul style="list-style-type: none">- Varieties/Grades- Declared Application	
Feedstock Composition for Pyrolysis Oil	
Manufacturing Process Utilized	
Declared Product Quality (Attach test report)	
Laboratories Used for Pyrolysis Oil Testing	
Users of the Pyrolysis Oil Manufactured	

NOTE – Additional questions may be included by project allottee

Annexure II

Suggested Questionnaire for Pyrolysis Oil Exporter and Importer

Name of Exporter/Importer	
Location	
Contact Details	
Details of Pyrolysis Oil Exported/Imported <ul style="list-style-type: none">- Varieties/Grades- Quantity of import/export- Declared Application	
Declared Product Quality (Attach test report)	
If Exporter, Technical Regulation/Standards Followed for Export	
If Importer, Name and Contact Details of Manufacturer	
If Importer, Details of Users in India to whom Supplied	

NOTE – Additional questions may be included by project allottee

Annexure III

Suggested Questionnaire for Users of Pyrolysis Oil

Name of Industry/Company	
Location	
Contact Details	
Supplier of Pyrolysis Oil	
Applications where Pyrolysis Oil is being Used	
Any Problems Faced with Pyrolysis Oil Quality	
Any other Feedback	

NOTE – Additional questions may be included by project allottee

Annexure IV

Characteristics of Pyrolysis Oil

Sl. No.	Pyrolysis Oil Characteristics	Test Method
i.	Acidity, inorganic, mg of KOH/g	ISO 6618 / ASTM D974* / IP 139
ii.	Acidity, total, mg of KOH/g	IS 1448 (Part 2)* / ASTM D664 / ASTM D974 / IP 139
iii.	Ash, percent by mass	IS 1448 (Part 4)* / ASTM D 482 / IP 4
iv.	Carbon residue (Ramsbottom or micro) on 10 percent residue, percent by mass	IS 1448 (Part 8)* / IS 1448 (Part 122) / ISO 10370 / ASTM D524 / IP 14 / ASTM D4530 / ASTM D189
v.	Pour point	IS 1448 (Part 10)* / ASTM D 5949 / ASTM D 5950 / ASTM D 5985 / ASTM D97 / ASTM D7346 / IP 15
vi.	Copper strip corrosion for 3 h at 50 °C	IS 1448 (Part 15)* / ASTM D130 / IP 154
vii.	Flash point, Abel, °C	IS 1448 (Part 20)* / ISO 3679 / IP170 / IP523/ EN 13736
viii.	Flash point (Pensky Martens (closed), °C	IS 1448 (Part 21)* / ASTM D93
ix.	Kinematic viscosity, cSt, at 40°C	IS 1448 (Part 25/Sec 1)* / ISO 3104 / ASTM D445 / ASTM D7042 / IP 71
x.	Kinematic viscosity, cSt, at 50 °C	IS 1448 (Part 25/Sec 1)* / ISO 3104

xi.	Total contamination, mg/kg	EN 12662* / IP 440
xii.	Sediment, percent by mass	IS 1448 (Part 30)
xiii.	Density at 15°C, kg/m ³	IS 1448 (Part 16)* / IS 1448 (Part 32) / ISO 12185 / ASTM D4052 / ASTM D1298 / ASTM D91 / IP 160
xiv.	Total sulphur, mg/kg	ISO 13032 / ISO 20884 / ISO 20846 / ASTM D5453 / ASTM D2622 / ASTM D7220 / IS 1448 (Part 34) / IS 1448 (Part 153) / ASTM D 4294 / IS 1448 (Part 33) / ISO 8754*
xv.	Water content, mg/kg	ISO 12937 / ASTM D6304 / ASTM E203*
xvi.	Cold Filter Plugging Point (CFPP)	IS 1448 (Part 110)* / ASTM D 6371 / IP 309
xvii.	Oxidation stability, g/m ³	IS 1448 (Part 154)* / ASTM D2274 / IP 388 / ASTM D7545
xviii.	Oxidation stability by Rancidity meter, hours	EN 15751
xix.	Polycyclic Aromatic Hydrocarbon (PAH), percent by mass	EN 12916* / IP 391 / ASTM D6591
xx.	Lubricity corrected wear scar diameter (wsd 1.4) at 60°C, microns	IS 1448 (Part 149)
xxi.	Gross calorific value	IS 1448 (Part 6)* / IS 1448 (Part 7) / DIN 51900
xxii.	pH	pH meter ^a
xxiii.	Chloride content	WDXRF / EDXRF / Micro-coulometry
xxiv.	Metal content (Pb, Hg, As, Mg, Zn, Ca, Cu, Fe)	ICP/MS or ICP/AAS

^a To be used with frequent calibration