Climate Action Research and Education Seed Call Application Form

I. General information

- Project title: Small scale demonstration of the conversion of contaminated polystyrene into a high quality plastic-crude.
- Applicant: Dr.ir. Luis Cutz
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II. Summary of the proposed research project/program

1. Project description

Plastics are at the core of our daily life and their contribution to waste streams (absence of recycling) has become one of the greatest challenges, since the turn of the millennium. In the most developed regions as Europe, one third of the plastic waste (10 Mt) was recycled in 2020, 23% ended up in landfills and the rest was sent to energy recovery operations such as incinerators[1]. Plastic waste that is not collected usually ends up in agricultural soils or as marine litter[2]. **In this sense, the plastic sector is a driver of environmental impact and a mitigator if sustainable practices and processes are developed for efficient recycling**.

Nowadays, the recycling of plastics is mainly done via mechanical recycling, typically ending up in down-cycling to products with a lower added value. Mechanical recycling faces significant difficulties when dealing with mixed plastics typically with a high level of contaminants (e.g., colorants, additives, food waste, and others). Thus, the challenge relies in reducing the waste volume of complex mixed fractions of plastics while generating high quality products with minimal environmental impact. **The objective of this proposal is to perform a batch scale demonstration of chemical recycling using a real stream of contaminated waste plastic and converting it into high-value products** such as a biofuel. For this, I propose to use hydrothermal liquefaction (HTL) technology, which is a robust and versatile technology to convert highly heterogeneous and contaminated materials into useful products (oil, gas and char). HTL uses high-pressure water as a solvent to crack polymeric structures into hydrocarbons[3]. Compared to competing technologies (e.g. pyrolysis), HTL requires no drying or pelletization, avoiding extra energy costs. Once the biofuel is produced, from now on “plastic-crude”, this can be broken down into monomers, which later on can be turned back into virgin polymers/plastic. Thus, addressing the waste plastic crisis and contributing to the circular economy.

- **Objectives and expected results**

The aim of the project consists on evaluating the potential of contaminated plastic waste as a source for plastic-crude production via HTL technology. We will evaluate experimentally the effects of reactor operational variables upon the plastic-crude yield. This data will then be integrated into conceptual process designs to assess the potential of HTL in large-scale applications.

- **Approach and proposed activities**

I aim to provide a proof-of-concept methodology to valorise contaminated waste plastic for plastic-crude production via HTL technology that meet the quality standards of biofuels. This will be done by using polystyrene as a case study. This, since this type of plastic is a major waste plastic stream worldwide but also is produced at the TU Delft campus in huge quantities. The polystyrene will be **sourced from Maria's Homemade restaurant located at the Aerospace Faculty from TU Delft**. The challenge of this stream is that polystyrene is typically contaminated with food residue. Additionally, I will use a Design of Experiments (DoE) approach to identify the influence of major operation variables (temperature, residence time and waste plastic loading) affecting the plastic- crude yield. The data collected from the experimental campaign will be used in process simulations to predict the behaviour of HTL at large-scale.

- **Explanation on the role of collaboration in the project (e.g., inter- and trans-disciplinary, internal/external to TU Delft);**

This project aims to include an interdisciplinary team, combining expertise on both the experimental part and process modelling. To do so, I'll collaborate with Prof.dr.ir Wiebren de Jong (P&E Dept., Faculty 3ME) part of the Flagship team "*Circularity of plastics and non-fossil energy carriers*" to design the experimental campaign. Then, the data obtained from the experimental work will be transferred to Dr. Ana Somoza-Tornos (Chemical Engineering Dept., Faculty TNW) and her team, who will build a process simulation model of a large-scale chemical recycling plant based on HTL. The conceptual process design will consider the properties of the feedstock, reactor configuration, catalyst, solvent, HTL product distribution and properties of the plastic-crude. The process model will deliver insights regarding heat integration potential and economics.

- **Potential impact and relevance for future research/education activities**

The funding for this project will allow the first small scale demonstration of the conversion of waste plastic into a plastic-crude at TU Delft. The project results will also set the foundations for further exploration towards the conversion of complex mixed waste plastic back into plastics via HTL. As part of the project, it is considered to share the results in form of a journal publication but also to make them publicly available to the Climate Action Community and symposiums/conferences.

2. Relevance for Climate Action Programme

The project proposal contributes to *Theme II: Climate change mitigation* and *Flagship project: Circularity of plastics and non-fossil energy carriers*. This, since closing the plastics loop will reduce fossil fuel consumption and related greenhouse gas emissions. Furthermore, this project aims to develop innovative technology that will strengthen the position of TU Delft as a key player in the circular economy research field.

3. Follow-up

The results of this project will serve to engage stakeholders involved in the plastics supply chain and as basis to apply to (inter-) national grants focused on circular economy topics such as the *HORIZON-CL6-2024-CircBio-02-2-two-stage: Increasing the circularity in plastics value chains*.

III. Budget

Item	Justification	Amount requested (€)
1	Consumables	2,700.00
2	Characterization of HTL products (bio-oil and biochar)	
	Ultimate analysis plastic-crude and biochar (ALS Inspection B.V., 300€/sample incl. VAT)	13,200.00
	1 full set of plastic-crude physico-chemical characterization (includes density, viscosity, etc., incl. VAT)	1,900.00
	XRD and XRF of biochar (Materials Science Engineering Lab TU Delft, 100€/sample)	4,400.00
3	Research Assistant (9 months, part-time)	5,400.00
4	Hardware for Chemical Engineering Dept. (1 Desktop)	2,400.00
	Total	**30,000.00**

IV. References

1. Plastics Europe. *Plastics - the Facts 2022*. (2022).
2. FAO. *Assessment of agricultural plastics and their sustainability. A call for action.* (2021).
3. Seshasayee, M. S. & Savage, P. E. Oil from plastic via hydrothermal liquefaction: Production and characterization. *Appl. Energy* **278**, 115673 (2020).