SETAC EUROPE 29th ANNUAL MEETING
26–30May 2019 | Helsinki, Finland
One Environment. One Health.
Sustainable Societies.

GOBIERNO DE ESPAÑA | MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES

Ciemat — Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

The environmental behaviour of PEEK as an innovative material in a new portable hydrogen fuel cell

Daniel GARRAÍN*, Silvia CABELLO, Yolanda LECHÓN

CIEMAT – Energy Systems Analysis Unit, Av. Complutense 40, E28040 Madrid (Spain). www.ciemat.es. *daniel.garrain@ciemat.es

Background & Objective

E.LI.GE project (http://projects.ciemat.es/web/elige) proposes a new way for portable energy generation in the 1-100W power range. It is based on a hydrogen fuel cell (FC) with high power density. The key concept of the project is the integration of the current collectors in the electrodes to decrease both weight and volume of the distribution plates and the end-plates, which largely contribute to reduce the FC power density. The new completely passive design also eliminates the weight and volume of unnecessary auxiliary systems and their associated power consumption. to make of this system a viable alternative for powering portable devices. The main general objectives of E.LI.GE are the following:

- Fabrication of electrodes for portable FCs, which have special characteristics to accomplish with the requirements. In particular, water permeable anodes and air-breathing cathodes are being developed.
- Assembly of membrane-electrodes-current collectors with low internal resistance and low compression requirements. These assemblies allow to increase the power density of portable FCs.
- FC stack plane, light and with high energy density. The stack works in plane configuration to adapt the characteristics of the electrodes (Figure 1).
- Portable application (hydrogen + FC), which is being demonstrated and tested (Figure 2).

Figure 1. FC scheme and main parts.

Figure 2. Application in a mini-airship developed in CIEMAT.

A previous preliminary study [1] presented the Environmental Footprint (EF) results of the manufacturing process of the FC stack. Regarding the different selected parts, the anode was the main contributor to the EF due to the plates composition, mainly of *Polyetheretherketone (PEEK)*. It also included membranes, silicon joints, screws, washers, nickel drain, plastic frame and electrodes.

PEEK has received particular attention over the past few years due to its both excellent mechanical and chemical properties to high temperatures [2], which has been used as an innovative material due to its light weight and density. It could be synthetized in laboratory, by reaction of 4,4'-difluorobenzophenone (DFBP) with hydroquinone in the presence of potassium carbonate (Figure 3), and then dried under vacuum at 100°C for 24 h.

The objective of this work is to show the environmental influence, in terms of greenhouse gases (GHG) emissions, of the manufacturing of this material in comparison to other counterparts polymers, in order to consider the impact in the FC.

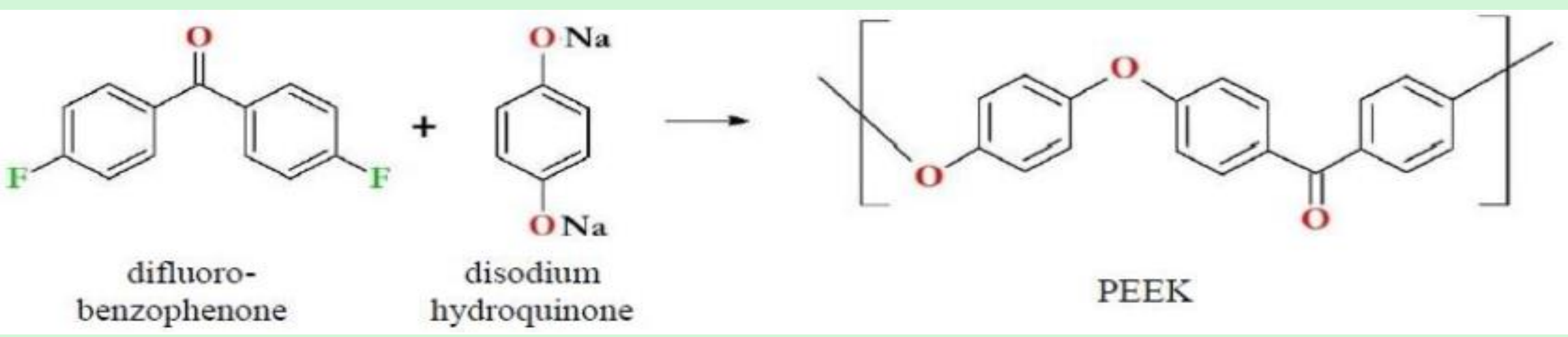

Figure 3. Synthesis of PEEK (Source: https://www.azom.com/article.aspx?ArticleID=17671).

Materials & Methods

An environmental assessment has been done by means of the calculation of the EF from a Life Cycle Assessment (LCA) approach.

This study presents only Climate Change (CC) impact category when different considerations are taken into account regarding production of the anodic material:

- **PEEK 1**: high energy efficiency when synthetized.
- **PEEK 2**: medium energy efficiency when synthetized.
- **PEEK 3**: low energy efficiency when synthetized.
- **PMMA** (PolyMethyl MethAcrilate): from literature (IDEMAT database)
- **PC** (Polycarbonate): from literature (ecoinvent database).

Results

Figure 4 shows the relative contribution to CC of the production of PEEK when energy consumption is optimized (case of PEEK 1).

Figure 5 presents the total GHG emissions when the thermoplastics are compared.

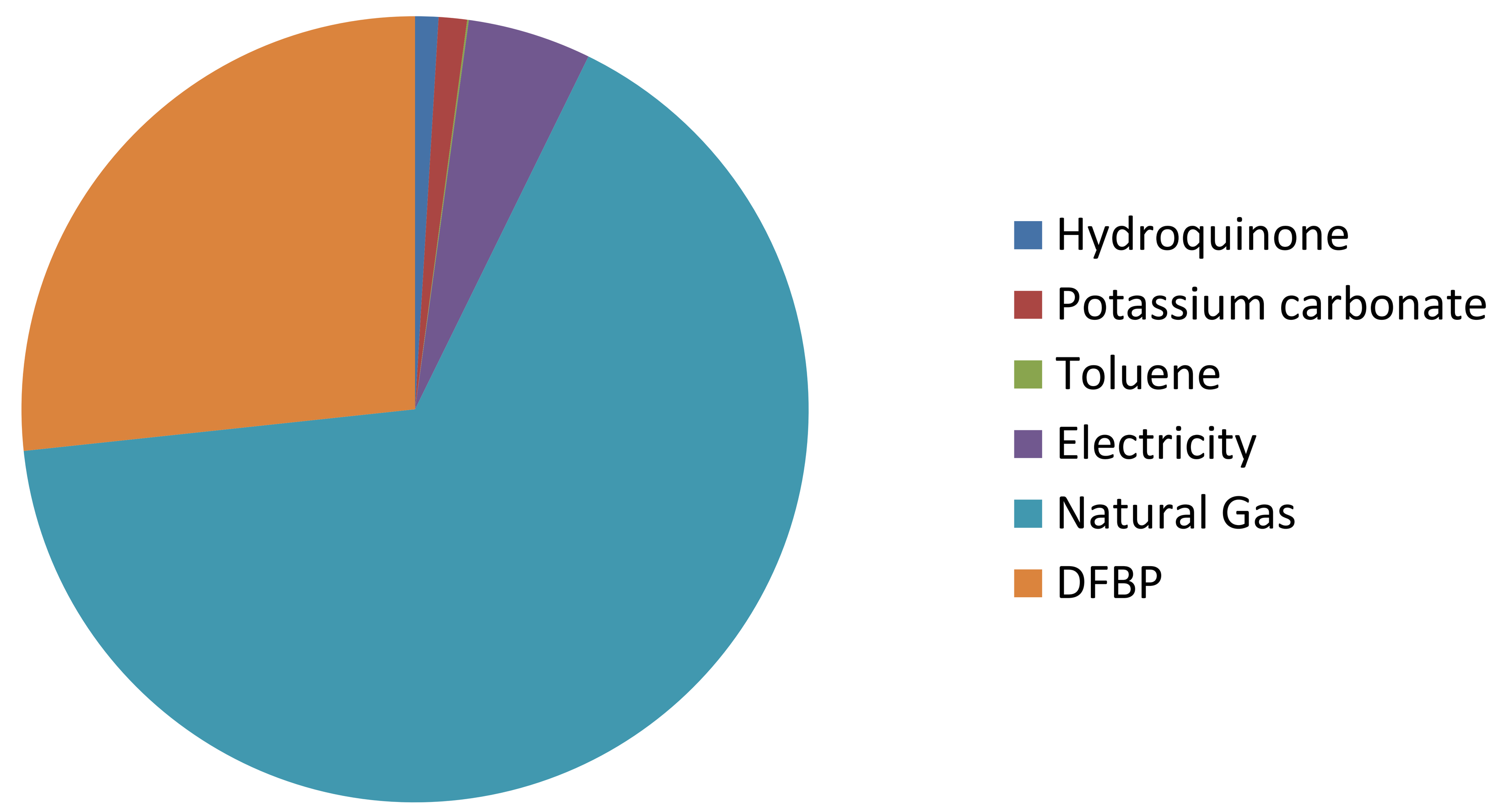

Figure 4. Relative contribution in CC of materials and processes to synthetize PEEK, via laboratory.

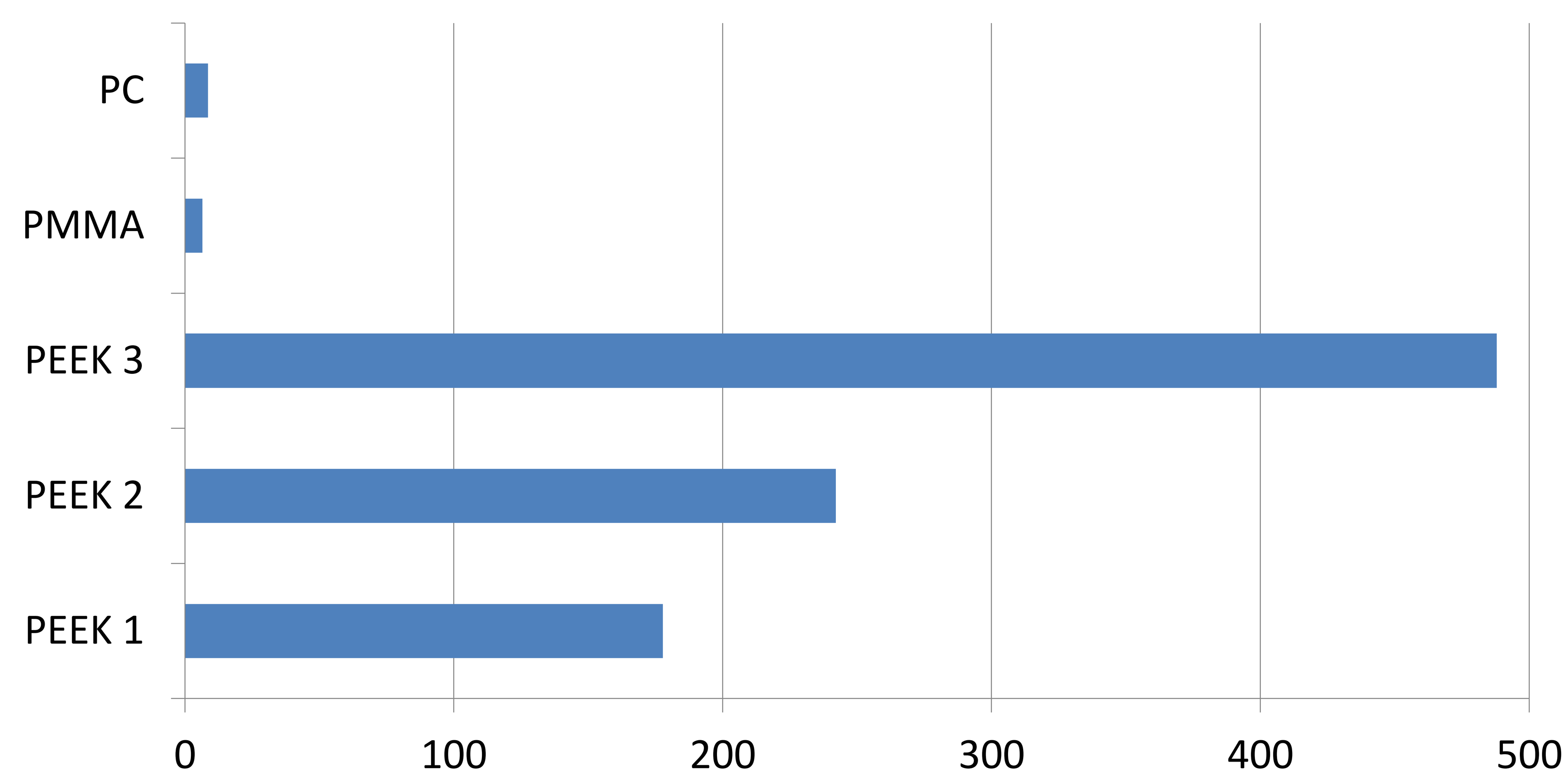

Figure 5. Comparison of GHG emissions (kg CO_2 eq / kg) of the different thermoplastics manufacturing.

Discussion & Conclusions

PEEK, when synthetized via laboratory, has worse environmental performance when compared to other thermoplastics. Other impact categories have similar results in percentage terms.

Nevertheless, this behaviour is made up for its better mechanical and thermal properties, which would imply a more useful life span. This will be considered in the future stages of the project.

References

[1] Garraín D, Cabello S, Herrera I, Lechón Y. *Life Cycle Assessment of a new portable hydrogen fuel cell: Preliminary streamlined results*, SETAC Europe 24th LCA Symposium, 24-26 Sep 2018, Vienna (Austria).

[2] Kim DJ, Lee BN, Nam SY. *Characterization of highly sulfonated PEEK based membrane for the fuel cell application*, International Journal of Hydrogen Energy, Volume 42, Issue 37, 14 September 2017, Pages 23768-23775. https://doi.org/10.1016/j.ijhydene.2017.04.082.

QR code to download the poster