Supercritical water reaction applied to biomass

Juan García Serna[1*] and Danilo Cantero[1]

[1] *Pressure Technologies Group (PressTech), Institute of Bioeconomy, Department of Chemical Engineering and Environmental Technology, Universidad de Valladolid*

**Corresponding author: juan.garcia.serna@uva.es*

Highlights

- Ultrafast Reaction Times SCW hydrolysis with reaction times as low as 0.1 seconds at 400°C.
- High yields and tunable selectivity by controlling water properties.
- Instantaneous Cooling using Joule-Thompson effect for rapid temperature drop from 400°C to 100°C.
- Industrial scalability with a proven technology for large-scale biomass hydrolysis applications.

1. Introduction

Supercritical water is not a magic water, it is a tool that has been studied over the last decades to be able to perform chemical reactions and extractions in a solvent that does not present toxicity or environmental problems, as is the case with many of the traditional organic solvents. The dielectric properties, pH, solubility, etc. are modified to a great extent by varying pressure and temperature [1].

When batch reactions with supercritical water are studied, what happens is that the heating and cooling periods are several minutes long. In that time there are many side reactions that can occur in the biomass, e.g. condensation, acidification, etc. and it is very difficult to obtain a product with high selectivity and reproducibility.

The Sudden Expansion Reactor (SER) (See Figure 1) is able to perform split-second reactions in the biomass, modifying its structure, chemical properties and functionality.

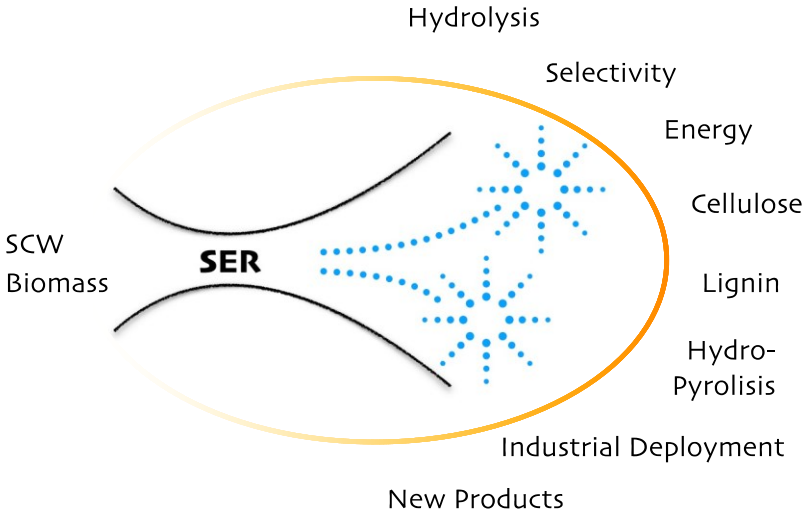

Figure 1. SER Sudden Expansion Reactor

2. Methods

In our group we have been studying for the las 15 years different reactions in batch, semicontinuous [2,3] and continuous [3,4] using subcritical and supercritical water as shown in Figure 2.

Figure 2. PHUN-0 (left) Subcritical water hydrolysis pilot plant in cycles and PHUN-2 (right) Supercritical water hydrolysis pilot plant in continuous

3. Results and discussion

The biorefinery group of PressTech has advanced its supercritical water hydrolysis (SCW) technology to a new level of flexibility, automation and control. Our current equipment performs hydrolysis under conditions from 100 to 400 ºC using biomass in big pieces (semicontinuous) or in powder (continuous) from a range of flow conditions to tackle 1 to 5 dry kg/h.

This setup allows rapid evaluation of various materials as potential feedstocks. Our primary strategy focuses on studying feedstocks from food or agricultural industries. Emphasizing this strategy, we concentrate on "upcycling" materials, transforming biomass into more valuable products: high-performance materials, fuels, and food ingredients.

We will present several examples on biopolymers (pectins, hemicelluloses and celluloses), prebiotics, polyphenols, antioxidants, food ingredients, etc. Different materials are created using these ingredients.

4. Conclusions

Water under pressure and temperature can be a good solvent to run reactions, taking part in the reaction as well as a solvent. Pilot scale laboratory facilities can help in the boosting of the applications.

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Keywords

Supercritical Water, Biorefinery, Pilot scale, Bio-based materials