Reactor configuration for subcritical water extraction of pectin-derived compounds from onion peel wastes: a comparative study

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20th European Meeting on Supercritical Fluids
Maribor, Slovenia, May 26 - 29, 2024

1. Problem and Solution proposed

Onion peel wastes (OPW) represent 10% of the onion production (104 Mt worldwide, 2020) and end up in landfills because they are not suitable for human consumption or animal feeding. OPW are a source of quercetin and **pectin derived compounds (PDC)**, biopolymer of 1,4-D-galacturonic acid (GalA) highly demanded by the industry.

KEY ASPECTS

- ✓ **Pectin has growing worldwide demand (40,000 t/y), increasing at 5% rate**
- ✓ **New sources of pectin and new recovery strategies are demanded**

EXTRACTION

Subcritical Water, promotes the hydrolysis of onion peel wastes to extract pectin and avoids the use of inorganic acids as the conventional extraction process.

Control of the experimental conditions is critical, since it may lead to the formation of undesired degradation products (mainly furfural and formic acid) and molecular weight loss of PDC.

PROPOSAL

Continuous reactors offer a better control of the experimental conditions (temperature, heating and cooling rates, as well as the residence time).

Our goal is to compare the results obtained from batch and continuous reactors

2. Experimental

Batch Reactor

- ✓ 500 mL extractor
- **Experimental Conditions**
  - 15 g OSW + 350 mL H_2O
  - 105 to 165 °C, at 5MPa; up to 180 min
  - Best conditions: 125 °C for 150 min
- **Kinetic Study**
  - ✓ Panchev's model, simultaneous extraction and degradation
  - ✓ Energy of activation (E_a): 78 kJ/mol

Continuous Reactor

- ✓ Continuous supercritical water plant: Ultrafast reactor
- **Experimental Conditions**
  - Onion peels (5%) feed: 12 kg/h
  - Water feed: 25kg/h
  - Screening conditions (total, 12):
    - 100 – 250 °C
    - reactor length 1.2 to 4 m (residence time: 1.5 – 6.5 s)
    - 15 MPa

Tools

- **Severity Factor** (@ 150 °C)

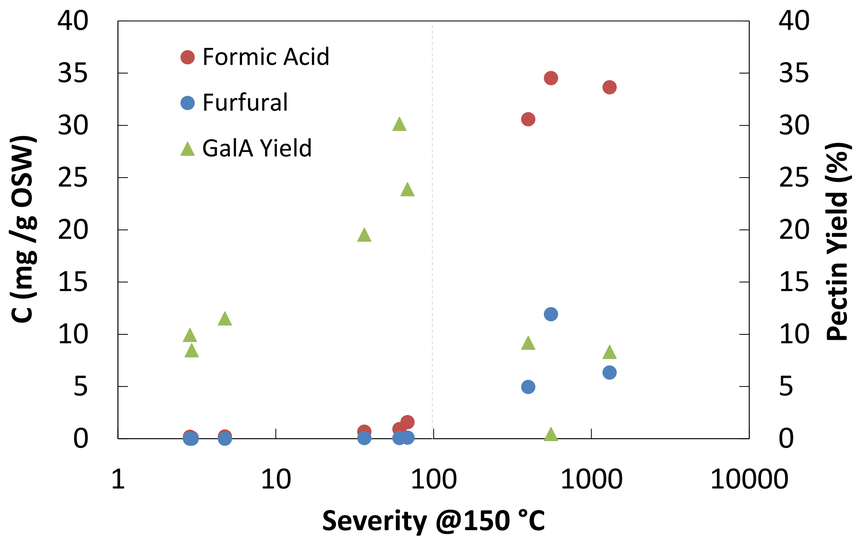
$$Severity = t \cdot exp^{E_a \cdot \frac{T - T_r}{R \cdot T_r^2}}$$

- **Analysis**
  - **HPLC:** free sugars + degradation products (formic acid; furfural) + GalA
  - **GPC:** PDC molecular weight (MW)
- **Calculations:**
  - Pectin Yield: GalA extracted/GalA in OPW

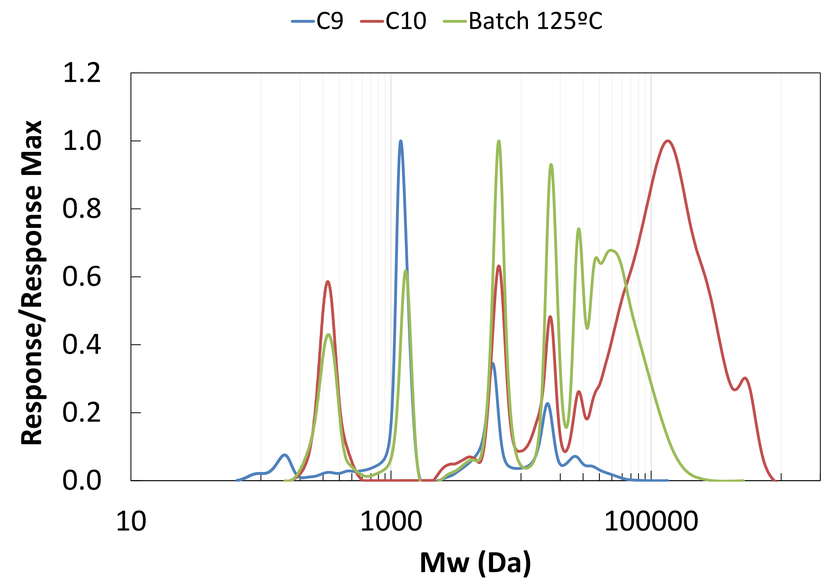
3. Results

Reactor	τ	T (°C)	P (MPa)	Severity (@ 150 °C)	Pectin Yield (%)	Average MW (kDa)	Formic (mg/g OSW)
Batch	150 min	125	5	2427	33±0.4	78±3	4.3±0.1
Cont. (C9)	5.7 s	198	15	60	30±0.6	108±4	0.85±0.12
Cont. (C10)	5.4 s	242	15	554	2.8±0.1	7±1	33±2

- ✓ The best results for PDC extraction are shown in the table for both reactor configurations. The continuous reactor leads to a similar yield but produces PDC with a higher molecular weight and fewer degradation products than batch reactor.
- ✓ However, in the continuous reactor, an increase in temperature results in the complete degradation of PDC.



- ✓ In the continuous reactor, a **severity of 100** sets the boundary conditions: beyond this point, the yield drops, and degradation products are rapidly formed.
- ✓ The MW of the PDC decreases with an increase in the severity conditions, leading to the formation of low MW families.



4. Conclusions

- The continuous reactor achieved a similar conversion to that of the batch reactor but operated at almost 200 °C with a residence time of around 6 seconds. The average molecular weight of PDC was 108 kDa in the continuous reactor compared to 78 kDa in the batch configuration, with a significant reduction in the presence of degradation products.
- As the intensity of the extraction conditions increases, the molecular weight decreases and degradation products formed increases dramatically.
- The continuous reactor offers precise control of experimental conditions, resulting in high conversion rates to PDC and low formation of degradation products, which will simplify downstream processing.

ACKNOWLEDGEMENTS

Agencia Estatal de Investigación (Spain), projects **PID2020-116716RJ-I00**, **TED2021-129311B-I00** and **TED2021-129837B-C42**

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