Crustacean shell deproteinization by subcritical water conditions in continuous ultrafast reactors

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Abstract

Exploring renewable biomass and waste for higher-value products and energy is crucial for circular economy development. Crustacean shell wastes (exoskeletons from prawns, shrimp, crabs, and lobsters) are abundant (6-8 million tons/year) but currently underutilized, often disposed in landfills or dumped into the ocean, these wastes pose environmental and health risks [1]. Exoskeletons are primarily composed of chitin (20-30%), minerals (30-50%, mainly $CaCO_3$), proteins (15-30%), and minor components carotenoids like astaxanthin [1] [2]. The growing interest in marine peptides (2–20 AA) for functional foods [3] necessitates efficient, selective fractionation processes using eco-friendly solvents and energy-intensified methods to valorize this waste. Subcritical water has been employed in batch mode to process shrimp shells for protein recovery; recent studies found that at 260 ºC and 5 minutes (isothermal time), 96% of the protein was removed from shrimp shells as hydrolizate [4]. However, it was not evaluate the potential presence of chitin degradation products in the liquid, since it has been demonstrated at temperatures slightly above (283ºC) and processing times in the same range [5]. Our group has developed ultrafast sudden expansion micro-reactors (UF-SEMR) with sub and supercritical-water for biomass continous processing, yielding excellent fractionation results for lignocellulose biomass [6]. The goal of this study is to utilize UF-SEMR under subcritical conditions for the selective recovery of the protein fraction from shrimp shells while preserving the original chitin structure for further valorisation. To achieve this, a water suspension of shrimp shells (1-10% wt.) is continuously fed into a continuous ultrafast hydrothermal plant. Heating is accomplished by mixing the compressed room temperature biomass suspension (0.5-1 kg/h) with a hot pressurized water stream (3-6 kg/h), reaching the desired temperature (140-300 ºC) just before entering the UF-SEMR. Instantaneous cooling is achieved through sudden decompression. Various reactor volumes are employed to control residence time within the range of 0.2–60 s. Supercritical hydrolysis is already established at an industrial scale [7]. Proteins will be quantified by the bicinchoninic acid assay (BCA) and free amino acids by the ninhydrin method in the liquid product. Chitin content, its molecular weight and acetylation degree (DA) will be evaluated in the solid product.

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