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Concentration of phycocyanin and caffeine from aqueous solutions with osmotically-assisted membrane distillation

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Introduction

Osmotically-assisted membrane distillation (OMD) is gaining attention as an alternative concentration step in various industrial fields, owing to its mild operating conditions, i.e., low temperature and ambient pressure.

In this study**, OMD was investigated to concentrate aqueous waste extracts:** phycocyanin (PYC) from a Galdieria extract and caffeine (CAF) from a spent coffee grounds extract.

Phycocyanin

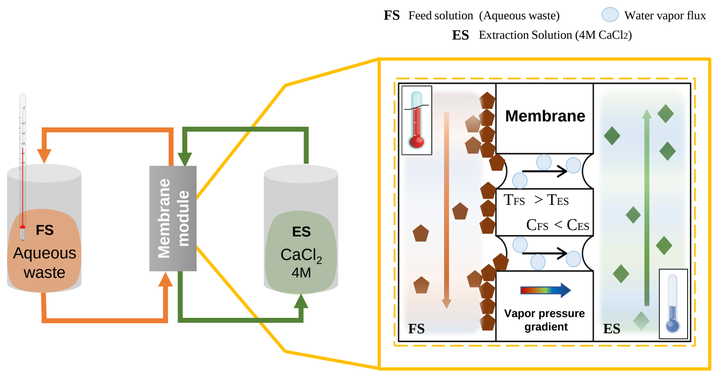
PYC is a microalgae protein which has anti-oxidation and anti-inflamation properties. However, its sensitivity to environmental conditions, such as temperature, pH, and light, hinders its recovery with means of high-temperature and solvent-based techniques.

Caffeine

CAF, on the other hand, is not heat-sensitive but in its recovery from spent coffee grounds, an excessive heat can increase the loss of thermolabile and volatile bio-active compounds related to coffee flavor, thereby affecting the quality of the concentrate when used as additive in the food and cosmetics industry.

Methods

- Batch degradation tests of the two extracts were initially performed at 35°C, 45°C, and 55°C to evaluate the effect of temperature on the target compounds.
- For each extract, OMD tests were then conducted at same temperatures using a 4 M $CaCl_2$ extraction solution. The recovery was set at 75% (concentration factor 4).



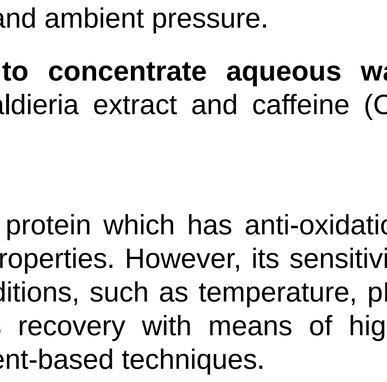
- The process effectiveness was evaluated by monitoring the concentration of phycocyanin by spectrophotometry and caffeine by HPLC-UV/Vis analyses. The phycocyanin concentrate quality was evaluated with a standard purity index based on the ratio between absorbance values at 620 nm and at 280 nm wavelengths, IA_{620}/A_{280}. Instead, the quality of the coffee extract was estimated measuring the total flavonoids content (TFC) as equivalent of routine with an aluminum chloride colorimetric assay. Additional total organic carbon (TOC) measurements were performed to detect any transfer of organic compounds to the extraction solution.

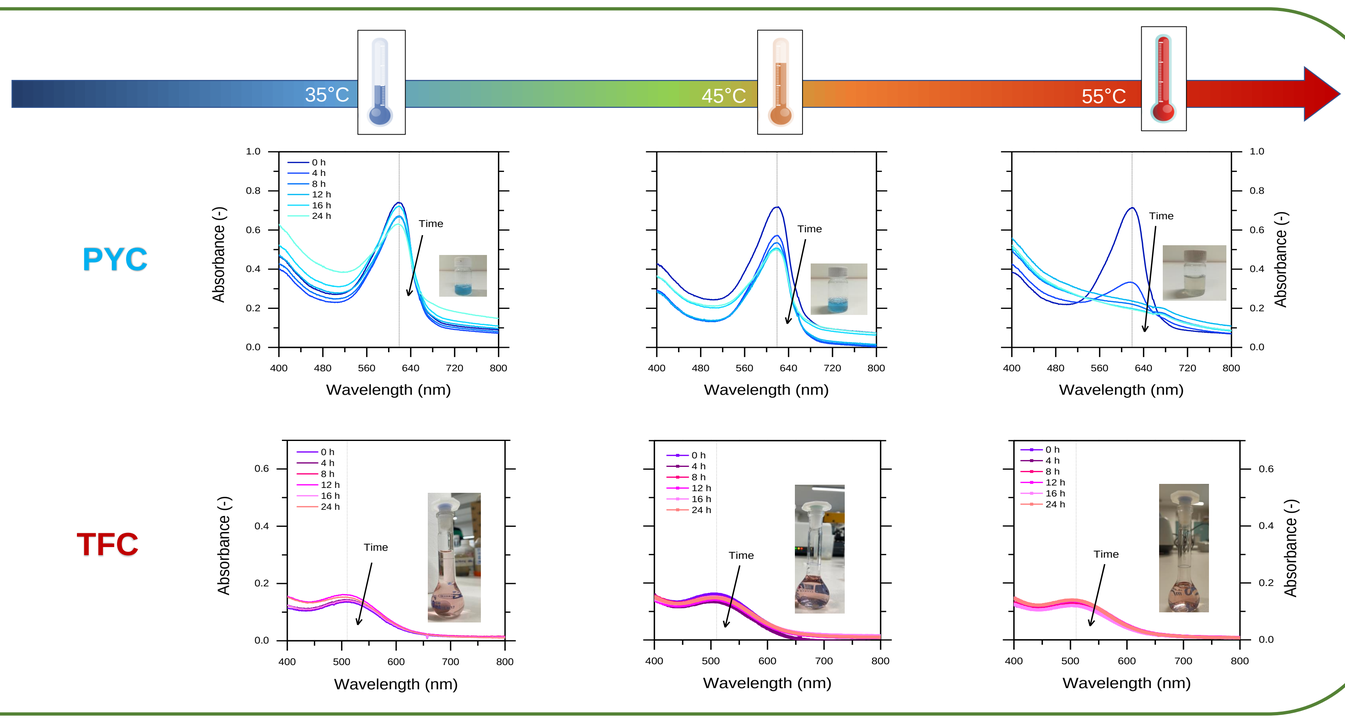
Results: Degradation test

Degradation tests confirmed that PYC is highly thermos-sensitive, with a decrease in its pristine concentration of 15%, 30% and 72% at 35°C, 45°C, 55°C, respectively. As for coffee extract, a slight degradation was observed only at 55°C, with a decrease of 5% in TFC and of 25% in CAF concentration.

PYC

CAF



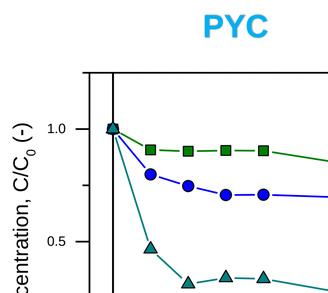


Results: OMD Concentration tests

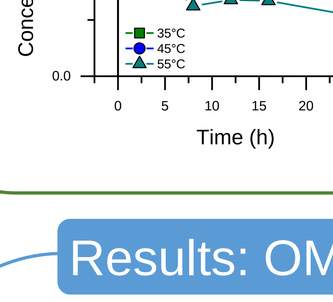
Unlike in the coffee extract concentration process, some restrictions were observed for PYC extract both in terms of concentration yield and concentrate quality. In particular, at 55°C, PYC degradation was predominant, while at 45°C, a lower quality of the final product was observed compared to that obtained at 35°C. Moreover, in the case of PYC, the measured fluxes highlighted the presence of a stronger fouling phenomenon which was clearly visible in the membrane appearance at the end of the experiments. For both extracts, the TOC values matched with the achieved recovery and confirmed the absence of organic matter transfer to the extraction solution.

Flux

PYC

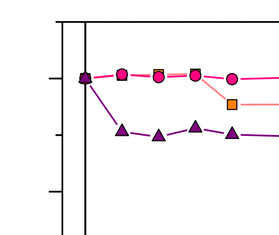


CAF

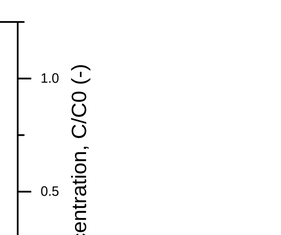


Concentration and Quality

PYC Concentration

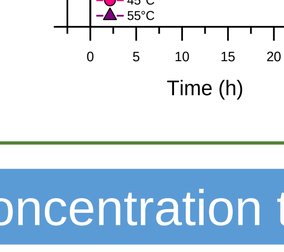


PYC TOC

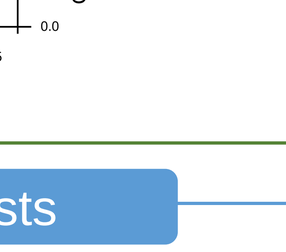


Purity IA_{620}/A_{280}

CAF Concentration



CAF TOC



TFC

Conclusions

Obtained results showed the possibility to concentrate both targets, although with some limitations for PYC extract. The OMD process resulted effective in PCY concentration, particularly at 35°C and 45°C even though different final product qualities were reached, but it resulted not feasible at 55°C due to the strong PYC degradation. On the other hand, the coffee extract concentration was effective even at higher temperatures, without affecting the concentrate quality measured as TFC. In all tests, the absence of organic compound transfer to the extraction solution was proven, thus attesting to the promising deployment of OMD for the concentration of high-value sensitive compounds.

The use of a draw solution on a distillate side allows application of a lower temperature on the feed side, thus maintaining high fluxes while avoiding target substance degradation.

Bertozzi et al., *Concentration of phycocyanin and coffee extracts in aqueous solutions with osmotically-assisted membrane distillatio*n (Submitted to Separation and Purification Technology).

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SCAN ME

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