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Carbon dots-assisted hydrophobic carbon membranes for percrystallization

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Abstract

Membrane processes are increasingly consolidated in the market due to their high efficiency in separation processes. In food and pharma industries, for example, processing at mild temperature favors the separation of sensitive compounds. Percrystallization is a recently developed membrane-based technique, which has shown promising by obtaining highly concentrated products, in a single step, at low temperature. For certain compounds, this process even allows obtaining solutes, such as sodium chloride (NaCl), in crystallized form [1,2]. Hydrophobic carbon membranes, obtained from the deposition of a solution containing high carbon content precursor over a porous support, followed by pyrolysis, have presented interesting results in the percrystallization of different solutes. This work aims to investigate the use of carbon dots (CD) as a crystallization aid during the percrystallization process. Porous ceramic tubes were covered with a solution containing sucrose and carbon dots (0, 0.05, 0.10, 0.15, and 0.30 wt.%), and pyrolyzed at 700 °C in a nitrogen atmosphere. This process aims to obtain a homogeneous and organized layer of carbon on the membrane surface, making it more hydrophobic and with smaller pores. To study the carbon structures formed after pyrolysis, the solutions used to functionalize the membranes were pyrolyzed at 700 °C, and then subjected to transmission electron microscopy (MET) analysis. The prepared membranes were characterized in terms of morphology through field effect scanning electron microscopy (FEG), and in terms of NaCl flow during the percrystallization process. Visual inspection of the outer layer of the tubes indicated that the membranes prepared only with sucrose presented a homogeneous and gray aspect layer. The membranes prepared with the sucrose solution containing the carbon dots had the unexpected presence of dark spots distributed over the surface (Fig. 1).

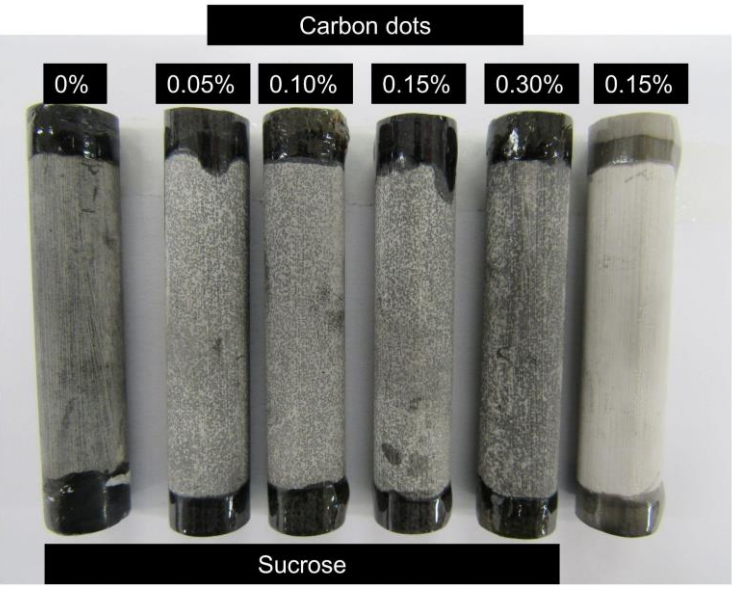

Figure 1- Membranes functionalized with sucrose and carbon dots.

It is hypothesized that the carbon dots induced the formation of sucrose crystals inside the precursor solution. These crystals could have impregnated the larger pores of the membrane surface and, consequently, resulted in the points with the highest carbon concentration after the pyrolysis. These points of higher carbon concentration are also evident in the micrographs, in which an inhomogeneity in the covering of these membranes can be seen. This inhomogeneity was not noticed in membranes prepared with sucrose or carbon dots alone. The MET analysis indicated large carbon structures (>20 nm) of varied geometry were found. These particles were often associated with smaller structures (~5 nm) very close to their surface, indicating an interaction between sucrose particles and carbon dots. Furthermore, the

inhomogeneity of the coating prevented a more closed layer from being obtained, thus remaining with very open pores and preventing the percrystallization process due to the high flow of the solvent. On the other hand, the membrane prepared with 0.30% carbon dots, which presented the greater number of carbon clusters (filling a larger area of the membrane), presented a great behavior under the percrystallization process. The NaCl flux of the membrane prepared with 0.30% carbon dots was approximately 7 times greater than the membrane prepared only with sucrose (Fig. 2). More studies are needed to better understand the phenomena involved in the membrane preparation.

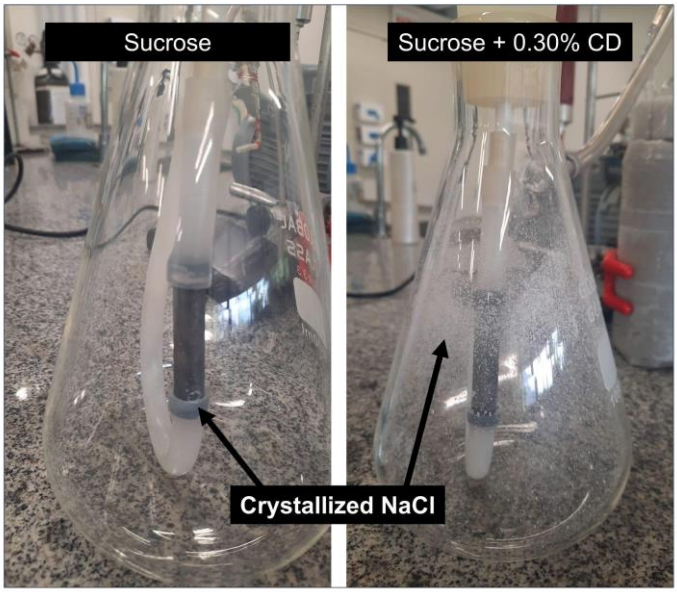

Figure 2 - NaCl percrystallization after 10 minutes of the process.

References

[1] R.S.K. Madsen, J. Motuzas, J. Vaughan, A. Julbe, J.C. Diniz da Costa, "Fine control of NaCl crystal size and particle size in percrystallisation by tuning the morphology of carbonised sucrose membranes", J. Memb. Sci. 567 (2018) 157–165.

[2] S.N.A. Jalil, J. Vaughan, J. Motuzas, "Production of pure water and dry salt from NaCl solutions via percrystallisation by supported carbon membranes", J. Water Process Eng. 54 (2023) 103968.