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Characterization of bulk and surface properties of anion-exchange membranes in initial stages of fouling by red wine

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Abstract

Electrodialysis finds broader use in reagent-free pH correction and tartrate stabilization of wines. The efficiency of these processes strongly depends on longevity of employed anion-exchange membranes. We report a comprehensive study of bulk and surface properties of a homogeneous Neosepta AMX-Sb and a heterogeneous MA-41P anion-exchange membranes after its contact with a red wine for 3, 10 and 72 hours. The ion-exchange capacity, conductivity, thickness, as well as surface roughness (AFM and optical microscopy), local surface and bulk pH (by color indicator), surface chemical structure (ATR FTIR), contact angle and surface charge are measured. In addition, the AMX-Sb membrane is characterized by voltammetry and pH-metry. It is found that polyphenols act un important role in membrane fouling. Initially, it is relatively small and mobile anthocyanins, which penetrate inside the membrane; then they are followed by larger and slower tannins and/or anthocyanin-tannin complexes. Polyphenols together with polysaccharides and other wine constituents form colloidal aggregates, which fill the membrane pores and are deposited by islets on the surface as a foulant layer. The appearance of this layer increases hydrophilicity of the surface while reducing its charge. The membrane conductivity decreases with increasing the duration of membrane contact with wine. However, the effect of this contact on the limiting current density, i_{lim}, overlimiting transfer and water splitting is unexpected. In early stages of fouling, i_{lim} of the AMX-Sb membrane increases and water splitting is found suppressed, electroconvection is essentially enhanced. The latter should be due to the isle-type structure of the foulant layer: surface electrical heterogeneity promotes electroconvection. However, the contact of the membrane with wine for several tens of hours results in formation of all-over foulant layer stimulating water splitting and reducing electroconvection.

Graphical abstract