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CFD simulations of spacer-filled channels for pressure retarded osmosis applications

A. Tamburini[a], R. Cattarinich[a], A. Cipollina[a], G. Vella[a], G. Micale[a*], E. Napoli[b]

[a]*Dipartimento di Ingegneria Chimica, Gestionale, Informatica, Meccanica (DICGIM), Università di Palermo (UNIPA) viale delle Scienze Ed.6, 90128 Palermo, Italy*
[*]*e-mail: giorgiod.maria.micale@unipa.it*
[b]*Dipartimento di Ingegneria Civile, Ambientale, Aerospaziale, dei Materiali (DICAM), Università di Palermo (UNIPA) – viale delle Scienze Ed.8, 90128 Palermo, Italy*

Salinity gradient power (SGP) is a renewable energy form, which can be drawn by the chemical potential difference between two different salt-concentrated aqueous solutions. Different technologies have been proposed so far in order to exploit this energy source: reverse electrodialysis, pressure retarded osmosis, capacitive double layer expansion and mixing entropy battery. Pressure retarded osmosis (PRO) takes advantage from the use of osmotic membranes allowing the passage of pure water from the low concentration solution channel to the high concentration one (draw solution). The latter is pressurized at a pressure lower than the osmotic one thus resulting in a water flux through the membrane guaranteeing a pressure energy increase, which can be exploited by means of water turbine.

As other membrane based processes, polarization issues reducing the theoretical driving force may occur. In particular, in the case of PRO, three different contributions on concentration polarization exist. The highest is placed within the membrane support layer, but there are some cases where also the concentration polarization on the draw solution side may be prominent.

Aim of this work is (i) identifying such cases and (ii) performing preliminary CFD simulations to find the geometrical feature a spacer should have to reduce such polarization effect.

- A preliminary literature review was performed to identify the membrane features and feed concentration providing the most higher concentration polarization on the draw solution side.

Simulations including passive scalar transport through the membrane were performed at these conditions.

- An in-house CFD model named Panormus was employed to investigate fluid dynamics and transport phenomena of a draw solution flowing within a channel provided with a net spacer. This CFD code was already employed and found to be robust and reliable for different applications. In this work an improved Immersed Boundary Conditions method was employed in order to discretize complex curvilinear geometry (typical of woven spacers) with structured hexahedral meshes. A grid dependence analysis was also performed in order to find the minimum number of computational cells (lower computational efforts) able to provide accurate results.

Different spacer features and operating conditions were investigated in order to identify a good compromise between concentration polarization and pumping power reductions.

Keywords: Salinity gradient power, PRO, osmosis, energy recovery, CFD, spacer-filled channels.

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The role of extracellular polymeric substances (EPS) on aerobic granules formation: comparison between a case of synthetic wastewater supply and another of industrial wastewater

Santo Fabio Corsino*, Michele Torregrossa, Gaspare Viviani

Dipartimento di Ingegneria Civile, Ambientale, Aerospaziale, dei Materiali (DICAM), Università degli Studi di Palermo, Viale delle Scienze, 90128, Palermo Italy
**Tel. +39 091 23896554; Fax +39 091 2386010; email: santofabio.corsino@unipa.it*

The paper reports the main results of an experimental study carried out on two granular sequencing batch airlift reactors (GSBAR) pilot plants. In particular, authors have focused on the role of extracellular polymeric substances (EPSs) in the granulation process and structural characteristics of aerobic granules. More in detail, a comparison between EPSs production by aerobic granules fed with synthetic and industrial wastewater was performed.

Aerobic granular sludge has attracted increased interests in recent years, for its high metabolic activity, large granule diameter of 0.2–9 mm, remarkable settleability and high biomass retention without any support media (Wei et al., 2012). Microorganisms residing within the granules, are expected to have increased protection against toxic substances (Adav et al., 2008). Moreover, due to the stratification of microbial populations inside the granule, the simultaneous removal of organic matter, nitrogen and phosphorus can be achieved in a single unit (de Kreuk et al., 2005; Di Bella and Torregrossa, 2013). All these advantages make the aerobic granular technology as a good option to treat industrial wastewaters. In recent years, lots of EPSs related researches have focused on its role in the aerobic granules formation and structural characteristics (Zhu et al., 2012). In particular, it is quite controversial the role of EPSs components, like proteins (PN) and polysaccharides (PS), on granules formation and stability. The EPSs production is related to influent wastewater characteristics, as well as operating conditions. Since metabolic stress induced by high organic load, and its fluctuations, as well as recalcitrant and toxic compounds, affects the EPSs production by microorganisms, granules formation and characteristics might be significantly influenced by influent wastewater nature. In a typical SBR reaction cycle, two different phases can be identified. In the former, that is characterized by high substrate availability (feast phase), microorganisms degraded