Ghulam Mustafa et al., Biomed Res, Volume 30
ISSN: 0976-1683

Antifouling grafting of nanofiltration membranes: New insights into membrane fouling mechanisms

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Membrane technology can be a flexible and viable long-term strategy for water treatment. However, prosperous and effective application of membrane technology has been hampered by membrane fouling induced by a wide spectrum of components in water. Particularly, dissolved natural organic matter (DNOM), a major organic constituent in surface water, has been considered to be a significant foulant, strongly reducing the membranes performance especially for NF (nanofiltration) membranes. Furthermore, it is well known that membrane fouling by DNOM is significantly enhanced in the presence of divalent cations (e.g. Ca^{2+}). Despite much research and industrial developments since the early 1960's, membrane fouling and especially irreversible fouling remains challenging and in-depth studies on mechanisms and solutions for irreversible fouling of inorganic membranes are lacking.

We have developed a smart surface functionalization method to decrease the fouling tendency by preventing the undesired adsorption or adhesion of foulants. Focus is put on two approaches for robust surface functionalization of ceramic NF membranes using Grignard reagents and phosphonic acids. The fouling tendency of polymeric and (surface functionalized) ceramic membranes by DNOM has been investigated. The effect of inorganic ions on fouling was different for hydrophilic and hydrophobic membranes. In hydrophilic membranes, irreversible fouling decreased in the presence of calcium, while an increase was seen for hydrophobic membranes. However, methyl functionalized membranes prepared via Grignard grafting remained unfouled with and without calcium. This gives interesting new insights into the membrane fouling mechanisms.

Secondly, the fouling tendency of these membranes was also tested using different model foulant solutions and real stream waters. Experimental results revealed that grafting of NF TiO_2 membranes by the mentioned techniques definitely decreases their fouling tendency. Especially methyl functionalized membrane (Grignard method) exhibited a significantly lower propensity to foul throughout all measurements using model foulants solutions. Moreover, the antifouling tendency of this particular membrane has proved also excellent in different real streams: real surface water (tested also at pilot scale), olive oil waste water and produced water. All the results can be elegantly explained taking into account the physico-chemical properties of membranes and foulants and their specific interactions.

Speaker Biography

Ghulam Mustafa graduated from University of Leipzig in the field of structural chemistry and spectroscopy and completed PhD form the University of Antwerp in the field of Chemistry (Materials Science, Membrane Science and Engineering, Separation and purification technologies, Water science) in the year 2016. He worked as a researcher in the Laboratory of Adsorption and Catalysis UA & Unit Separation and Conversion Technology VITO Belgium. From 2017 to present he is working as a assistant professor and as a researcher in Karachi University.

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