PROCESS INTENSIFICATION IN INTEGRATED PROCESSES

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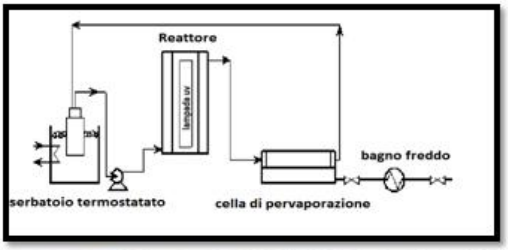
In the chemical industry, a process intensification is needed to meet important goals such as sustainable and eco-friendly processes. The "produce more with less" objective can be achieved by coupling reaction and separation in a so called "integrated process". Our research group has developed in the recent years important knowledge on the synergetic mechanisms that act in the integration of photocatalysis with membrane separation processes or other oxidative reactions. Photocatalysis is the most studied among the Advanced Oxidation Technologies (AOTs), due to many positive features: mild conditions, no chemical additives, possibility to use solar radiation to activate the reaction, modularity, simplicity for the operation and the control etc. The coupling of photocatalysis with pervaporation is simple and straightforward, even operating the two processes in separate equipments. This "membrane reactor" shows important benefits in the green synthesis of aromatic aldehydes and in water detoxification. In the first case the selectivity of the reaction is highly enhanced by the recovery by the membrane of the aldehyde while it is produced, avoiding its further oxidation in the photocatalytic reactor. The result are very satisfactory and the "AROMA" process (Advanced Recovery and Oxidation Method for Aldehydes) has been therefore patented and has been applied to the production of many aromatic aldehydes, such as vanillin and benzaldehyde. In water detoxification the membrane reactor has been used to remove recalcitrant pollutants from water streams. The rate of detoxification more than double with respect to the one obtainable without integration, thanks to a synergy between the two process, The optimization showed that a relatively low membrane area is sufficient to maximize the "intensification" index. It has been shown that also the coupling of photocatalysis with ozonization increases synergistically the rate of oxidation and the capability to control the formation of unwanted compounds. In our laboratories, many apparatuses are available for the experiments and the tests both for aqueous and gaseous effluents.



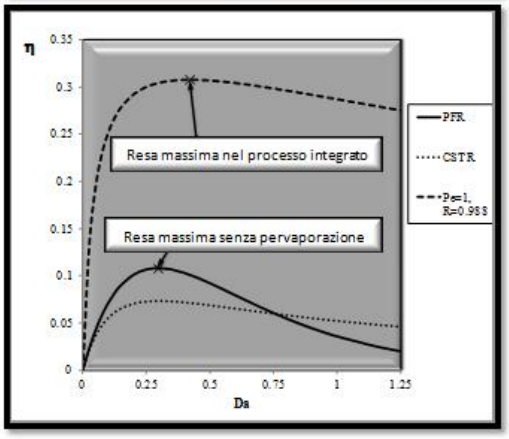


Fig.1 Scheme of an integrated process in our lab.

Fig.2 One of the experimental apparatuses.

Fig.3 Optimization of the yield of a membrane reactor.

MAIN PUBLICATIONS

Camera-Roda G., Santarelli F. (2012), Design of a Pervaporation Photocatalytic Reactor for Process Intensification, Chemical Engineering and Technology 35 (7) , pp. 1221-1228.

Camera-Roda, G., Augugliaro, V., Cardillo A., Loddo, V., Palmisano,G.,Palmisano,L.(2013). A pervaporation photocatalytic reactor for the green synthesis of vanillin, Chem. Eng. J. 224 , pp. 136-143.

Camera-Roda, G., Santarelli, F., Augugliaro, V., Loddo, V., Palmisano, G., Palmisano, L., Yurdakal, S.(2011). Photocatalytic process intensification by coupling with pervaporation, Catalysis Today 161 (1) , pp. 209-213.

Camera-Roda, G., Santarelli, F., Panico, M. (2009). Study and optimization of an annular photocatalytic slurry reactor, Photochemical and Photobiological Sciences 8 (5) , pp. 712-718.

Camera-Roda, G., Santarelli, F. (2007). Optimization of the thickness of a photocatalytic film on the basis of the effectiveness factor, Catalysis Today 129 (1-2 SPEC. ISS.) , pp. 161-168.

Camera-Roda G., Santarelli F. (2007), Intensification of water detoxification by integrating photocatalysis and pervaporation, J. Solar En. Eng. 129, pp. 68 – 73.

Camera-Roda et al., the “AROMA process” Patent

Camera-Roda G., Augugliaro V., Loddo V., Palmisano L., Pervaporation Membrane Reactors, in: A. Basile, Handbook of membrane reactors: Reactor types and industrial applications (Volume 2), Chap.3, Woodhead Publishing Series in Energy No. 56, 2013.

F. Occulti, G. Camera Roda, S. Berselli, F. Fava, Sustainable decontamination of an actual site aged PCB polluted soil through a biosurfactant-based washing followed by a photocatalytic treatment, Biotech. Bioeng., 2008, 99, pp. 1525 – 1534.

F. Parrino, V. Augugliaro, G. Camera-Roda, V. Loddo, M.J. López-Muñoz, C. Márquez-Álvarez, G. Palmisano, L. Palmisano, Visible-light-induced oxidation of trans-ferulic acid by TiO2 photocatalysis, J. Catal. 295, (2012), Pages 254–260.

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