Use of nanotechnologically constructed microreactors in MBR wastewater treatment system

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Microorganisms live in immobilized form adhering to surfaces and/or phase boundaries. This is also true for biological wastewater treatment, where the activated sludge where bacteria are attached to each other and forming bacterial aggregates, called activated sludge floc. This phenomenon however, inherently holds an uncertainty as the quasi-suspended spontaneously formed bacterial aggregates could disaggregate or shear off depending on the mechanical stresses (aeration, mixing, etc.). These uncertainties are resolved by introducing the artificial microstructures for activated sludge bacteria to adhere on it.

Artificial floc structure constructed according to the technological requirements by nanotechnological methodology would provide adequate surface for the bacteria to colonize and grow in a controlled environment of microscopic dimensions. Moreover, the nanotechnologically constructed artificial flocs are able to react to environmental changes, such as redoxipotential and pH alterations. Simple environmental factors could trigger changes in the shape and size of the artificial floc (i.e., reacting by swelling or shrinking) providing opportunity for single step (simultaneous) nitrification and denitrification.

The development of polymer gels provides opportunities to fabricate microscopic size bioreactors for wastewater treatment. PVA-PAS (polyvinyl alcohol- polyacrylic acid copolymer) polymers proved to be effective carrier material. The primary objective of our analyses is to study the nanotechnologically constructed microreactors in MBR systems. In this paper the results of a case study are presented where the operational problems of artificial flocs in an MBR system were investigated.

At first, the MBR system was tested with raw PVA-PAA pearls in order to investigate the operational problems: the distribution of the gels in the reactor (variable concentration gradients at different points of the reactor), interaction between the membrane surface and the PVA-PAA pearls (the pearls might attach to the surface of the reactor or membrane). As the result of the pilot tests the MBR system proved to be appropriate for PVA-PAA pearls.

After the aforementioned preliminary test, the MBR reactor system was tested with autotroph bacteria immobilised onto the surface of the PVA-PAA pearls in a longer period of time. The test operation was started with the inoculation phase by appropriately pretreated bacterial suspension for immobilisation of the wastewater bacteria onto the surface of the pearls. After the inoculation phase the immobilised bacteria were started to grow up on the surface of the PVA-PAA gels forming biofilms of various layers. Under the test operation the parameters (temperature, pH, concentration of nitrogen forms, hydraulic properties of the system) of the influent and the effluent wastewater were systematically measured. The bacterial activity and the reactor efficiency were calculated according to monitored parameters.

The development of the microbial biofilm on the surface of the PVA-PAA pearls was monitored by microscopic analyses. The morphology, texture, density and thickness of the bacterial biofilm highly depend on the environmental conditions (influent wastewater quality, flow conditions and apparent shearing forces). Based on the microscopic analyses the adequacy of the environmental conditions in MBR reactor was evaluated to obtain the development of appropriate biofilm structure on the surface of the PVA-PAA pearls. The paper presents the results of the microscopic analyses, the development of the biofilm and operational experiences.

The MBR system with the PVA-PAA microreactors was operational appropriately with no significant problem. Based on experimental results, the critical operational parameters were determined; flow conditions in the reactor, and optimization of shearing forces (aeration).

References

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