Supporting information

Effect of multicomponent fouling during microfiltration of natural surface waters containing nC_{60} fullerene nanoparticles

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Membrane module potting procedure

Lab-scale membrane modules were prepared according the procedure reported in the SI. by potting one membrane fiber using a two-component epoxy resin (Poli-service, Amsterdam, the Netherlands) in a transparent plastic polyvinylchloride tube of 23 cm in length and 1 cm in diameter to obtain a membrane filtration area of 10 cm2. The membrane housing contained a feed inlet connection (also the backwash outlet connection), a permeate outlet connection (also the backwash inlet connection) and two manually adjustable valves to release air bubbles that can form inside the fibers and/or in the membrane housing.

Filtration and fouling of surface water without nC_{60}

Figure 1 shows the total and irreversible fouling (both expressed as TMP increase) over the 6 filtration cycles of the 4 waters investigated without the addition of nC60.

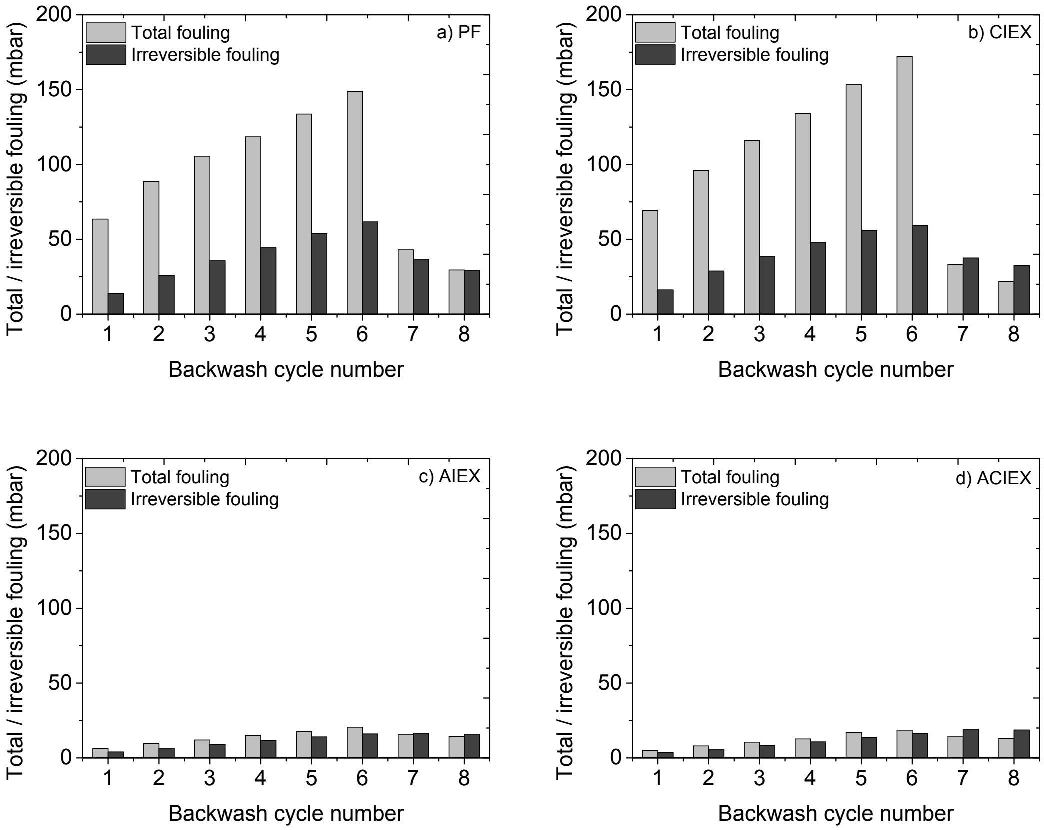

Figure S1: Total fouling and irreversible fouling (expressed as pressure increase) versus the backwash cycle number for the various surface water types without nC_{60} (cycles 1 – 6): a) pre-filtered water, b) CIEX treated water, c) AIEX treated water and d) A CIEX treated water. Irreversible fouling after the final flushing procedure is also reported and referred to as cycles 7 and 8.

The presence of NOM (PF and CIEX treated water, Fig. S1 a and b) results in high values of total fouling, which can be partially removed again by the backwash procedure (cycles 7 and 8). Total fouling is significantly reduced when the negatively charged NOM fractions are removed (AIEX and ACIEX treated waters, Fig. S1c and d). However, in these cases, the total fouling formed on the membrane is mostly irreversible, as indicated by the cycles 7 and 8. This can be a consequence of electrostatic charge interactions between the NOM fractions and the membrane. Removal of the negatively charged NOM diminishes the electrostatic repulsion between the foulants and the membrane. Moreover it was found that NOM with neutral constituents, such as polysaccharides, can cause adsorption on polymeric membranes (69). This therefore results in fouling more persistent to the backwash procedure.

Membrane rejection

Table S1 reports the nC_{60} rejection for the 4 different water backgrounds and for the 6 filtration cycles.

Table S1: Membrane rejection of nC_{60} for the four different waters.

	Water type			
	PF	CIEX	AIEX	ACIEX
Cycle 1	99.99	99.99	99.99	99.99
Cycle 2	99.99	99.99	99.99	99.99
Cycle 4	99.99	99.99	99.99	99.99
Cycle 6	99.99	99.99	99.99	99.99

In all cases, the observed nC_{60} removal efficiency is very high (99.99%) during all filtration cycles. This is in accordance with the removal efficiencies previously obtained for the filtration of nC_{60} in ultrapure water (26). The removal efficiency is also found to be independent of the type of water.

Fouling development (pressure profiles) in the presence of nC_{60}

Figure S2 reports the development of the slopes (dTMP/dt) of the pressure profiles in time for the 4 different water dispersions and for the 6 filtration cycles. Slope trends for all the cycles show similar behaviour.

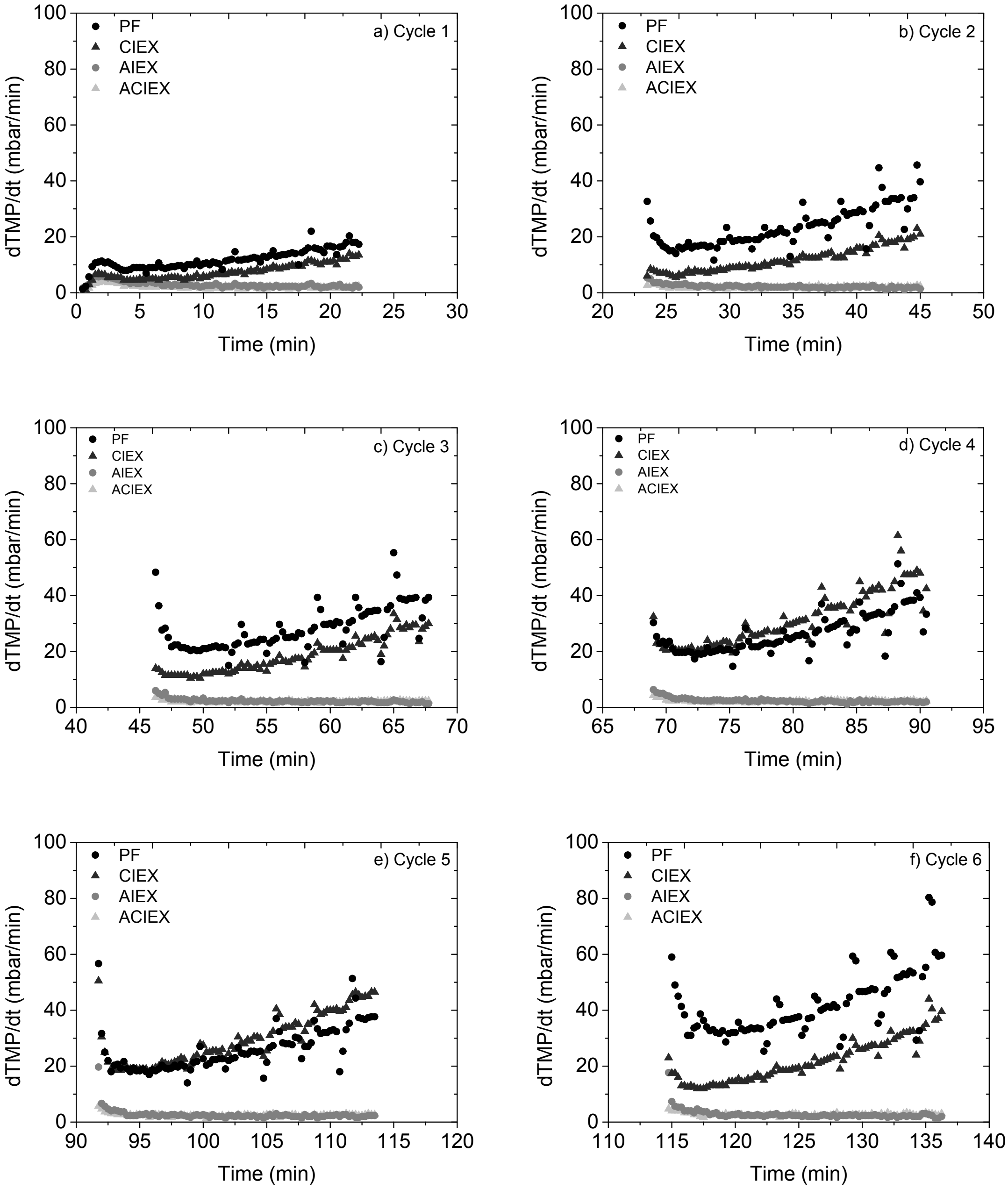

Figure S2: Change of the slope dTMP/dt of the pressure profiles with time for the 4 different water types in the presence of nC_{60} and different filtration cycles: a) Cycle 1; b)

Cycle 2; c) Cycle 3; d) Cycle 4; e) Cycle 5 and f) Cycle 6. The data of both anion exchange resin treated waters (AIEX and ACIEX) overlap.

When all NOM is present in the water (PF and CIEX waters), the slope dTMP/dt of the pressure profiles increases in time, indicating the formation of a compressible fouling cake layer. Removing the negatively charged fraction of NOM from the feed water (AIEX and ACIEX waters) results in a flat dTMP/dt profile, which indicates the formation of an incompressible cake layer.

Fouling development (pressure profiles) in the absence of nC_{60}

Figure S3 shows the development of the slopes (dTMP/dt) of the pressure profiles in time for the 4 different waters without nC_{60}.

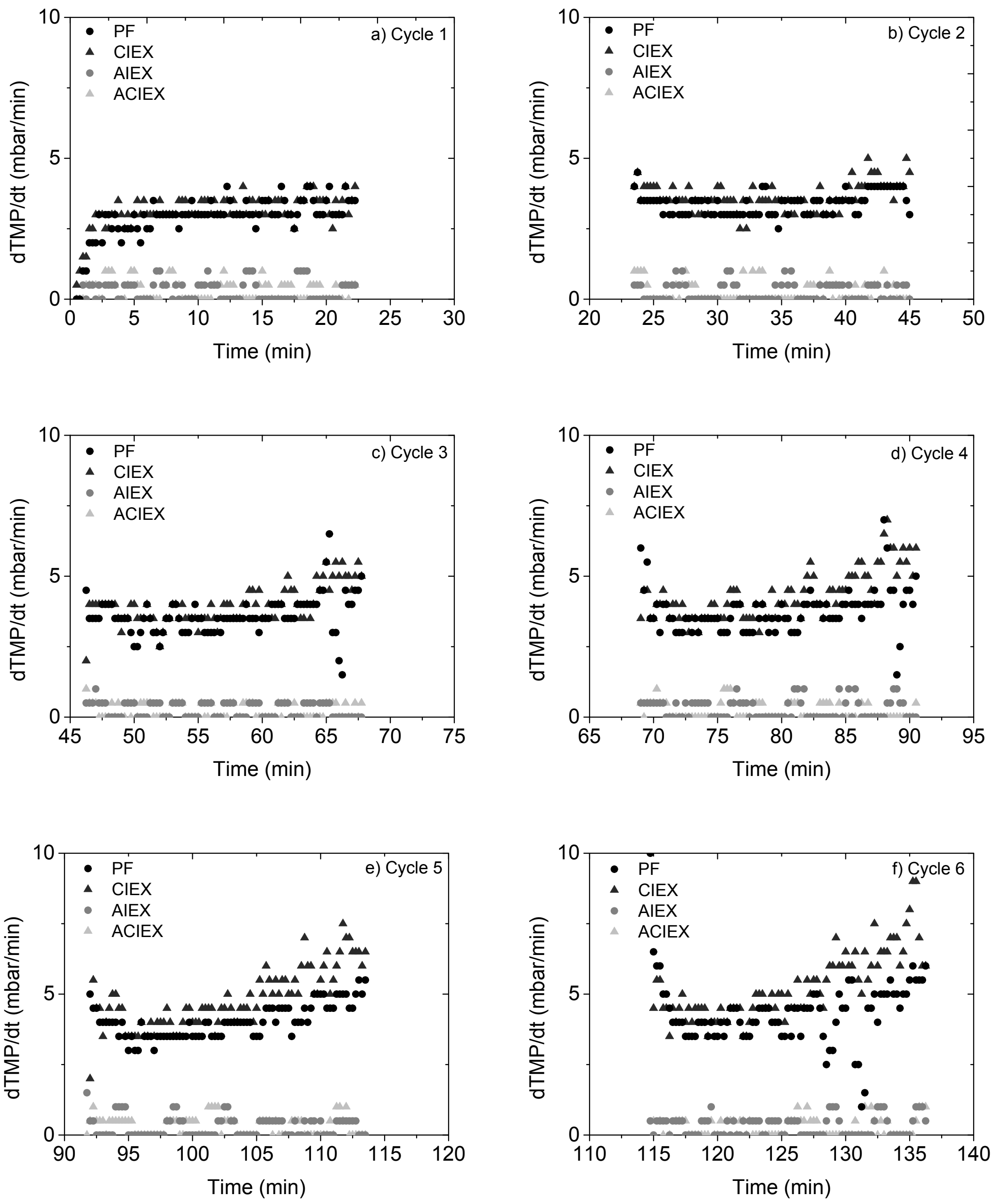

Figure S3: Change of the slope dTMP/dt of the pressure profiles with time for the 4 different water types and different filtration cycles: a) Cycle 1; b) Cycle 2; c) Cycle 3; d) Cycle 4; e) Cycle 5 and f) Cycle 6. The data of PF and CIEX treated water and those of anion exchange resin treated waters (AIEX and ACIEX) overlap.

In the case of water without any C_{60}, when the negatively charged fraction of NOM is removed from the water (AIEX and ACIEX treated waters), the slope dTMP/dt of the pressure profiles is substantially constant and remains constant during the full filtration. When all NOM is present in the water (PF and CIEX treated waters), the slope dTMP/dt of the pressure profiles keeps substantially constant in time for the first two filtration cycles. At cycles 3 and 4 the slope starts to increase in time. In cycles 5 and 6 the increase becomes more evident.

This behaviour of the slope in time indicates the occurrence of 2 different stages during the formation of the cake layer and its growth: first, the formation of an incompressible cake layer (until cycle 2), and subsequently this layer becomes compressible (after cycle 3). This is in agreement with previous studies (68), which demonstrated the link between the characteristics of the cake layer deposit and the amount of foulants deposited on the membrane an consequently the TMP increase.