Supporting information

Filter cake morphology

Table S1 shows the loading of filterable solids collected from the dried filter cake after the filtration experiments. The filterable solids loading was computed from the mass of the filter cake, divided by the volume filtered. The experimental error associated with the measurement was about 5 mg/L. In general, the filter cake solids loading ranged from about 50 mg/L for the un-aged samples to about 60 mg/L for samples with significant aging. The magnitude of this increase was too low to fully explain the change in fouling rates.

Table S1. Rate constants for cake filtration and other test parameters

Sample	Filterable solids (mg/L filtered)
Un-aged	49
90 hours	63
22 weeks	56
Accelerated aging	
30 min	46
2 hours	49
4 hours	52
8 hours	55
24 hours	64

Figure S1 shows cross-sectional SEM images of the filter cake from the natrually aged and accelerated aging experiments. Samples in which aging was accelerated due to bubbling with air showed compacted cake morphologies that resembling samples naturally aged for several weeks. However, no particles were entrained in membranes tested with bubbled water.

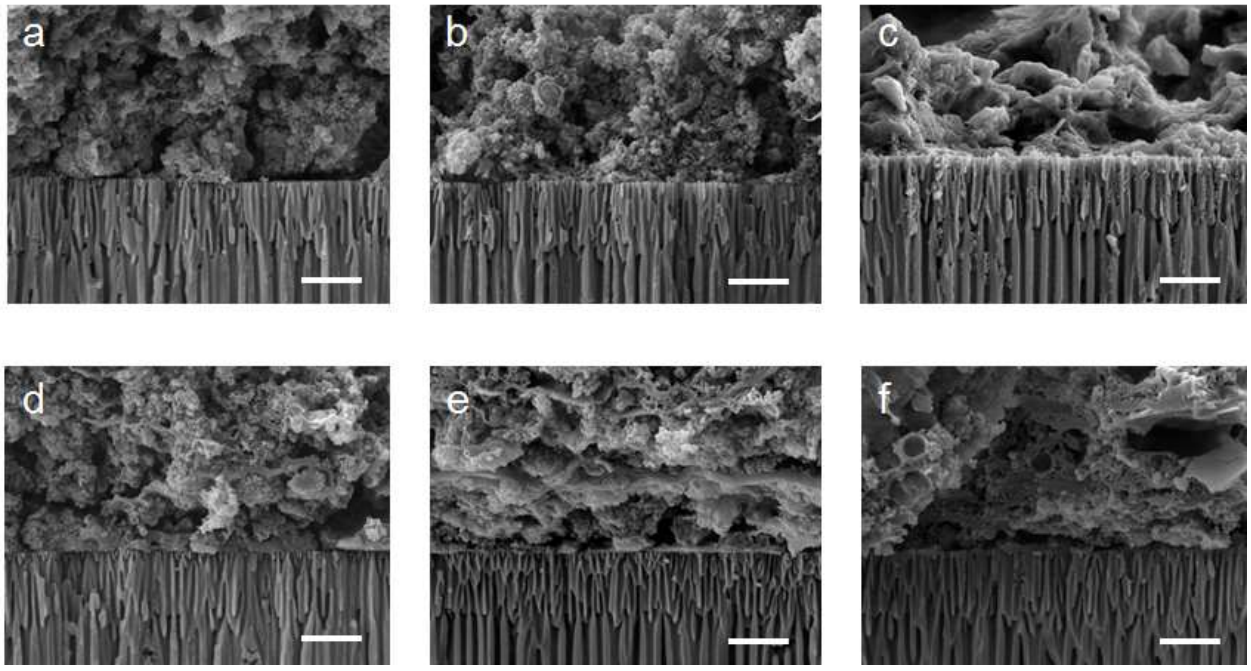

Figure S1. Cross-sectional SEM images of the filter cake for membranes tested using (a) un-aged water, (b) water allowed to stand quiescently for 90 hours open to air, (c) water stored for 22 weeks under a periodically refreshed air headspace, and water bubbled with air for (d) 2 hours, (e) 8 hours, and (f) 24 hours. The scale bar in each image is 1 μm.

Adsorption effects: Filtration data for pre-soaked membranes.

Membranes were pre-soaked for 24 hours in process water to evaluate the potential effects of adsorption of material into the inner porosity. Filtration was then performed using un-aged process water. Results are shown in Figure S2.

Six variations were tested:

1. Control experiment with no pre-soaking of the membrane.

2. Soaking for 24 hours in un-aged water, to quantify the adsorption effects from un-aged material.

3. Soaking for 24 hours in 16 week naturally-aged water, to determine the adsorption effects of aging reaction products.

4. Soaking for 24 hours in 16 week naturally-aged water, to separate the effects of dissolved aging reaction products from precipitated particles resulting from interactions with aging reaction products.

5. Soaking for 24 hours in water subjected to accelerated aging through bubbling of air for 1 day, to determine the adsorption effects of aging reaction products.

6. Soaking for 24 hours in water subjected to accelerated aging through bubbling of air for 1 day, to separate the effects of dissolved aging reaction products from precipitated particles resulting from interactions with aging reaction products.

Adsorption of material into the pores can manifest as a lower initial flux, relative to an un-soaked membrane. There were no differences in the initial fluxes in any of the tests; all of the experiments had initial fluxes in ranging from 1400 to 1600 LMH. Moreover, there were no differences in the shape of the flux decline curves, suggesting that the aging products did not directly change the interaction of the cake-forming fouling components with the membrane surface either.

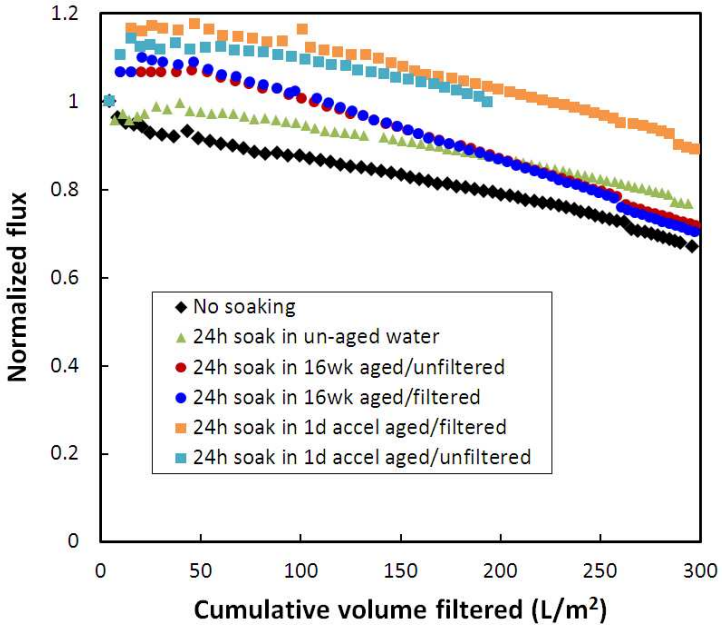

Figure S2. Flux decline curves for un-aged SAGD process water filtered through 100 nm ceramic membranes, pre-soaked for 24 hours in un-aged water (green triangles), 16 week naturally aged water (red circles), 16 week naturally aged water pre-filtered through a 100 nm ceramic membrane (blue circles), water subjected to accelerated aging through air bubbling for 1 day (orange squares), and water subjected to accelerated aging through air bubbling for 1 day pre-filtered through a 100 nm ceramic membrane (light blue squares).A control experiment with water filtered through a fresh membrane (black diamonds) is shown for comparison.

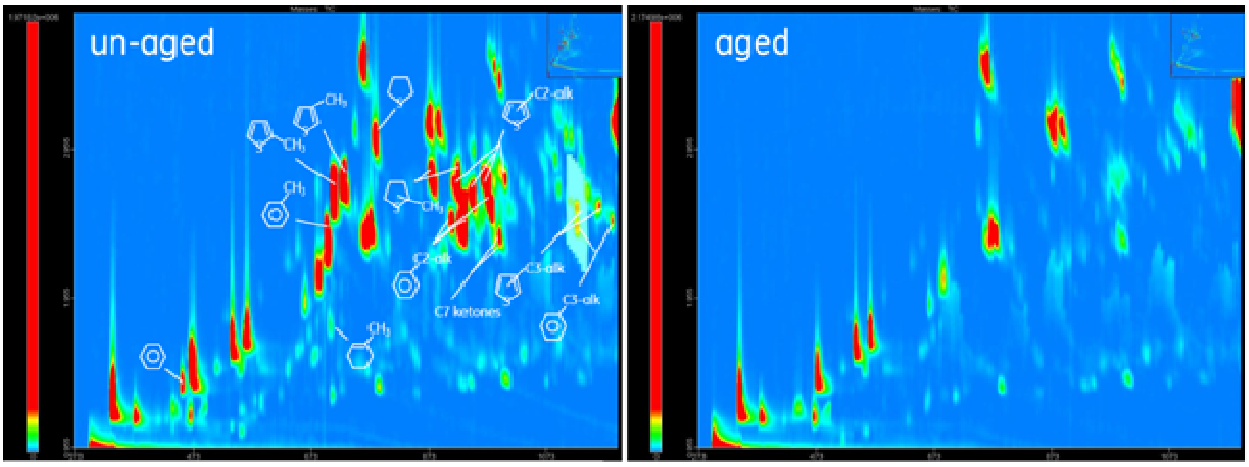

Figure S3. TIC plots from 2DGC-MS analysis of the un-aged (left) and aged (right) samples. Species that are absent in the aged sample are identified in the un-aged samples