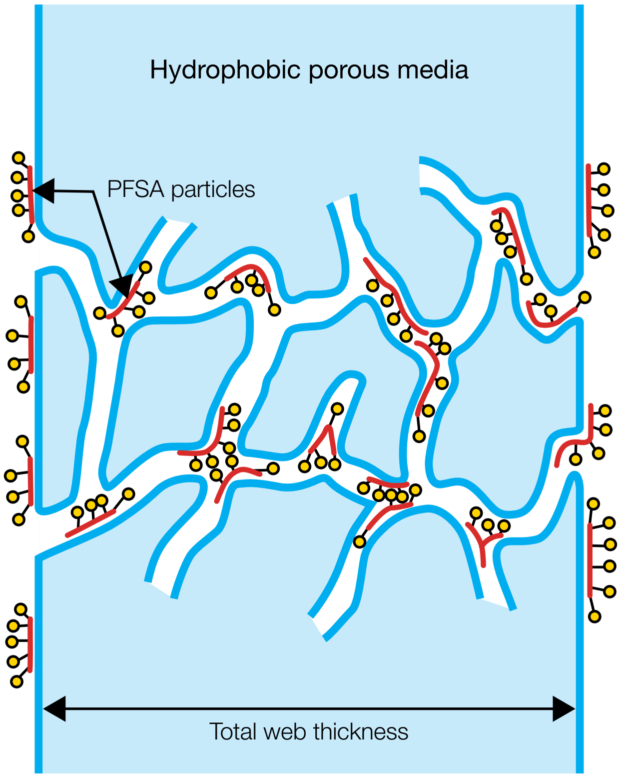
Hydrophilization of Porous Supports with Aquivion® PFSA Dispersions

Aquivion® PFSA is a two-phase, semi-crystalline fluoropolymer that has an affinity to both water and hydrophobic supports, such as PTFE. Due to this, its colloidal dispersion grades can be used as a surface treatment of hydrophobic substrates to improve their wetting behavior. PFSA's perfluorinated backbone will then orient towards and attach to the hydrophobic web surfaces while its hydrated ionic moieties (-SO_3H) placed at side chains (shown as yellow circles in Figure 1) create local hydrophilic domains on the outer and inner surfaces of the web.

Figure 1: Interaction of hydrophobic web and PFSA



Product Selection

Candidate grades of Aquivion® PFSA dispersions are D72-25BS, D79-25BS, D83-24B and D98-25BS; however, none of these are suitable for direct web treatments in the as-delivered form of aqueous concentrates. Instead, one will tend to use a well-wetting, diluted formulation with organic solvents, such as lower alcohols, ketones or other water-miscible solvents. The more hydrophobic the substrate, the more surface tension reduction tends to be required to obtain a satisfactory wetting behavior.

Formulation Development

During formulation development, it is particularly important to adjust the following:

- Surface wetting
- Dilution level
- Viscosity

Very dilute impregnation (treatment) formulations of PFSA polymer and an appropriately low viscosity are typically required to generate a hydrophilic polymer lay-on of a few grams per square meter, while still maintaining the substrate's micro- or nano-porosity (instead of partially or fully obstructing its pores). Still, the treated web's filtration performance will improve thanks to faster filtration speed at equal pressure difference or reduced need for overpressure to maintain the same liquid flow rate. Both cases will lead to filtrate-specific electricity savings.

To tailor the formulation viscosity, the PFSA polymer content and/or the solvent-to-water ratio need to be fine-tuned. To limit PFSA particle deposition and be able to reproducibly apply such a low level (few grams per square meter), the impregnation mixture may contain only 0.2 to 2.0 % of PFSA polymer by weight.

Some components in a formulation may get readily absorbed by the colloidal particles, leading to a distinct particle size growth. As a consequence these particles will no longer be able to pass the membrane's pores but would solely coat the web's outer surface. This problem will manifest by a strong flux loss (or strong increase of the Gurley number, respectively) of a treated web sample.

Application of the Impregnation Mix

The schematic in Figure 2 shows a common sequence of solvent removal steps used to stabilize the treatment after the imbibing step.

1. Start with a temperature (T1) that is slightly below the solvent's boiling point to evaporate low boiling solvents. Depending on substrate characteristics and targeted properties, bubbles caused by solvent vapor may need to be avoided, or they could be beneficial for the final properties of the hydrophilized porous membrane.
2. Raise the temperature (T2) to complete the removal of all solvents.
3. Some cases may optionally benefit from some annealing step that will improve the adhesion between the PFSA macromolecule's backbone and the inner and outer surfaces of the porous substrate. To do so one can raise the temperature (T3) further to about 190 to 210 °C (375 to 410 °F), and then hold for about 5 to 10 minutes to intensify the bonding, as long as the web is thermally stable at those temperatures.

This procedure will need to be adapted and optimized to the specific porous substrate, imbibing equipment and targeted requirements. In all cases, the glass transition temperature (T_g) of Aquivion® PFSA is in the range of 120 to 140 °C (250 to 285 °F) and the polymer is thermally stable up to 230 °C (445 °F).

If the substrate darkens after thermal treatment, it may indicate incomplete removal of solvents (especially when thicker membranes are produced) and/or insufficient oven ventilation (saturation of gas phase with solvent vapor). Depending on the solvent structure and chemistry, catalytic solvent reactions (notably decomposition) could occur during annealing (T3) at the strongly acidic SO_3H moieties of PFSA and cause darkening. In this case, it is advisable to extend the thermal treatment time at T2 or improve oven ventilation.

Types of Porous Webs

Web porosities as low as 0.1 to 0.05 microns can be treated using this procedure. The resulting flux loss and bubble point increase will depend on PFSA particle size in the formulation vs. the pore size distribution of the web – and possibly also its tortuosity. For special applications that involve smaller nano-sized pore structures, please contact Solvay Specialty Polymers for further assistance, or visit **www.aquivion.com** for additional information.

Figure 2: Schematic of the process for hydrophilization of hydrophobic substrates

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