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Designing durable poly(arylene perfluorophenylsulfonic acid)s with high proton conductivity under low humidity conditions

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An ideal membrane for high-power proton-exchange membrane (PEM) fuel cells should combine high proton conductivity under low humidity (RH) conditions with good chemical and mechanical properties [1]. To that end, we are currently preparing and investigating poly(arylene perfluorophenyl)s functionalized with sulfonic [2,3] and phosphonic [4] acid groups, respectively, as PEMs. The sulfonated polymers are prepared in efficient superacid-mediated polyhydroxyalkylations using commercially available perfluoroacetophenone and phenyl compounds, followed by sulfonation of the pendant pentafluorophenyl groups via a selective and quantitative thiolation–oxidation procedure [2].

The stiff and high-molar mass polymer structure containing highly acidic perfluoroalkylsulfonic acid groups (Figure 1) brings efficient ionic clustering, restricted water uptake and swelling, excellent resistance against radical attack, and very high proton conductivity. For example, the proton conductivity of well-designed PEMs reaches above 50 mS cm^{-1} at 80 °C and 30% RH, which clearly exceeds the benchmark Nafion NR212. Under these conditions, the proton conductivity increases linearly with the ion-exchange capacity. Overall, the results demonstrate that these materials possess an attractive combination of characteristics for use as high-performance PEMs for fuel cells and water electrolyzers.

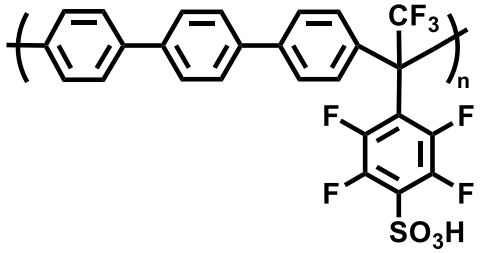

Figure 1. Molecular structure of poly(*p*-terphenyl perfluorophenylsulfonic acid).

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