

# 1 Introduction

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Fluorinated ionomers, particularly the perfluorinated ionomers developed in the 1960s, have revolutionized the chlor-alkali industry. In this process, the need for the use of hazardous materials such as mercury and asbestos has not only been eliminated, but the economics, particularly with respect to reduced energy consumption, has also been substantially improved. This application has now matured to such an extent that the complete replacement of the two older technologies is only a question of time.

More recently, a new application has emerged in the field of fuel cells. This development is still in flux and is the subject of considerable research in both industry and government institutions. It appears that the full potential of this application is yet to be realized.

The combination of hydrophilic and hydrophobic groups in the same polymer molecule of polymeric fluorinated ionomers results in unique properties and morphologies, which has attracted the attention of industry, researchers, and theoreticians. However, many questions regarding the inner workings of this material remain still unanswered.

## 1.1 Polymers

Both partially fluorinated and perfluorinated polymers, containing sufficient ionic groups to dominate the transport properties of the polymer, have been described in this book. Ionic groups may include sulfonic and carboxylic groups as well as sulfonamides and sulfonimides. Because of their importance in the synthesis and fabrication of these ionomers, their precursor polymers, containing sulfonyl fluoride or carboxylic ester groups, are also discussed. However, it should be emphasized that these precursor polymers are not ionomers and that they have properties which are quite different from the corresponding ionomers.

The synthesis of a perfluorinated ionomer containing phosphonic acid groups has been reported in the literature [1, 2]. Perfluorinated ionomers containing sulfonyl imide functional groups have also received some attention [3].

Within this broad scope, perfluorinated ionomers containing sulfonic or carboxylic functional groups have been covered most extensively because of their large commercial uses. Within this narrower group, the emphasis

has been placed on Nafion<sup>®</sup>, which has been available for about ten years longer than any of the other competitive materials in its class. DuPont has made both information and samples of Nafion<sup>®</sup> and its precursor polymer readily available to research groups and commercial users, which has resulted in extensive coverage of Nafion<sup>®</sup> in the literature.

## 1.2 Physical Shapes

Most fluorinated ionomers are sold as flat sheets and films, such as extruded or solution cast films, or as composite membranes containing fabric reinforcement added to one or more layers of the ionomer. Extruded capillary tubing is also available. Smaller quantities are sold in the form of pellets for applications such as catalysts or for conversion to liquid compositions. The end-use properties as well as the morphology and structure of these products are discussed in Chapter 4.

## References

1. Kato, M., Akiyama, K., Yamabe, M., Repts. Res. Lab., Asahi Glass Co. Ltd., **33**(2), 135, 1983.
2. Kotov, S., Pedersen, S., Qiu, Z., Burton, D., *J. Fluorine Chem.*, **82**, 13–19, 1997.
3. Thomas, B., Shafer, G., Ma, J., Tu, M., DesMarteau, D., *J. Fluorine Chem.*, **125**(8), 1231–1240, 2004.