SELF-STANDING SULFONATED GRAPHENE OXIDE MEMBRANES AS ALTERNATIVE PROTON CONDUCTORS FOR PEM FUEL CELLS

Andrea Basso Peressut[1], Matteo di Virgilio[1], Saverio Latorrata[1], Giovanni Dotelli[1]

[1] Department of Chemistry, Materials and Chemical Engineering "Giulio Natta", Politecnico di Milano, Piazza Leonardo da Vinci, 20133, Milano, Italy

E-mail corresponding author: andreastefano.basso@polimi.it

Abstract

State-of-the art proton exchange membrane fuel cells employ Chemours Nafion® as the ionomer of choice. However, Nafion® suffers a rapid performance degradation when the temperature is raised above 80 °C and the relative humidity is reduced below 50%. Huge efforts have been made to develop new materials able to work at such conditions, which would be beneficial for fuel cell operation, in terms of faster reaction kinetics, easier water management and simplified design. Among several approaches, graphene oxide (GO) has gained great interest due to its oxygen-bearing groups, which make it an ideal candidate to prepare self-assembling, hydrophilic membranes, although poor fuel cell durability and performance have been verified. This work presents a novel approach to improve the properties of GO and achieve an efficient operation at elevated temperatures and reduced humidity. Self-standing sulfonated GO membranes are produced by investigating two different functionalization processes (Figure 1), with the aim of introducing the same sulfonic groups (–SO_3H) of Nafion® and to enhance proton conductivity and water retention. On one end, sulfonation is performed by means of a reaction of GO with sulfuric acid; on the other, the intercalation of a naphthalene sulfonate-based (NS) molecule is exploited. Different acid-to-GO and GO-to-NS molar ratios are studied to identify an optimal composition, as well as two distinct process temperatures when NS molecules are used. Samples of both membrane types are extensively characterized from the morphological (ATR-FTIR, Raman, SEM-EDX, TG-DTG, XRD, static contact angle) and functional (water uptake, ion exchange capacity, electrochemical impedance spectroscopy) viewpoint, to acquire information on the effect of the employed procedures on GO properties, focusing on water retention and proton conductivity at the desired working conditions of low humidity and high temperature, in light of a future implementation in a running fuel cell.

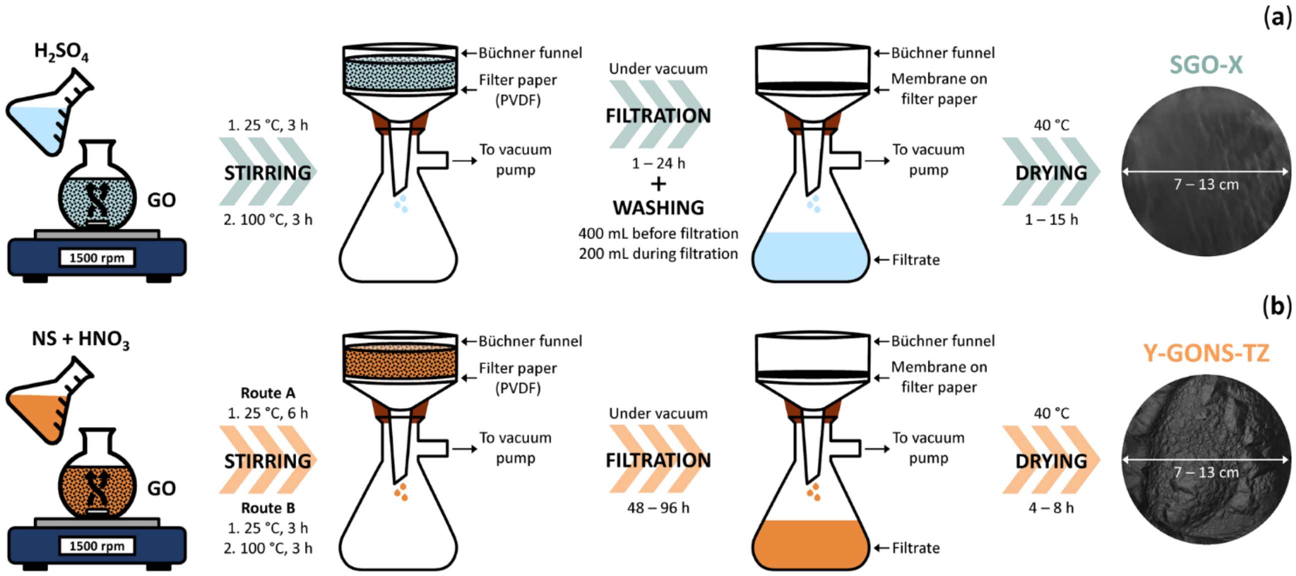

Figure 1 – Detailed summary of the employed functionalization procedures: a) SGO-X membranes prepared by sulfonation with sulfuric acid; X identifies the sulfuric acid-to-GO molar ratio. b) Y-GONS-TZ membranes produced by sulfonation with naphthalene sulfonate molecules; Y and Z specify GO-to-NS molar ratio and process route, respectively.