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Electrochemical and Morphological Studies of Ionic Polymer Metal Composites as Stress Sensors

Wangyujue Hong[1], Abdallah Almomani[1,2], Reza Montazami[1,3]

[1]Department of Mechanical Engineering, Iowa State University, Ames, Iowa 50011, USA
[2]Department of Aerospace Engineering, Iowa State University, Ames, Iowa 50011, USA
[3]Ames National Laboratory, Department of Energy, Ames, Iowa 50011, USA

Correspondence to: Reza Montazami (E-mail: *reza@iastate.edu*)

ABSTRACT

Ionic polymer metal composites (IPMCs) are the backbone of a wide range of ionic devices. IPMC mechanoelectric sensors are advanced nanostructured transducers capable of converting mechanical strain into easily detectable electric signal. Such attribute is realized by ion mobilization in and through IPMC nanostructure. In this study we have investigated electrochemical and morphological characteristics of IPMCs by varying the morphology of their metal composite component (conductive network composite (CNC)). We have demonstrated the dependence of electrochemical properties on CNC nanostructure as well as mechanoelectrical performance of IPMC sensors as a function of CNC morphology. It is shown that the morphology of CNC can be used as a means to improve sensitivity of IPMC sensors by 3-4 folds.

KEYWORDS: IPMC; CNC; Mechanoelectric sensor; Ionomeric sensor

1. Introduction

Ionomers, especially Nafion, have been subject of numerous investigations for their ionic properties and applications in ionic-electric devices such as fuel cells(1-4), actuators(5-9), batteries(10-13), super capacitors(14) and sensors(15-18). Among all such applications, ionic polymer sensors have received less attention mainly due to apparently inconsistent experimental results (19-22). Similar to ionic polymer actuators, ionic polymer sensors are consisted of an ionomer membrane coated by conductive network composites (CNCs) on both sides, where the whole structure (also known as ionic polymer-metal composite (IPMC)) is doped by either aqueous or ionic liquid electrolyte. The functionality of ionomeric sensors relies on, supposedly, random displacement of ions (and charged ionic clusters if ionic liquids are used) throughout the CNC layers when an external mechanical stress is applied. Electric field generated due to the motion of charged species is collected by the CNC and is detectable by conventional electronics. Due to the presence and displacement of both cations and anions in IPMC, theoretically there should be a zero net charge as opposite fields generated by displacement of cations and anions are expected to be statistically very close to each other in magnitude and cancel one another. In reality, however, there is a non-zero detectable net electric field. This electric field (mechanoelectric signal) exists because, due to their volume, charge and interactions with the ionomer, motions of cations and anions are different when subjected to stress(17, 23).