

**DEVELOPMENT OF SULFONATED POLY(ETHER KETONE ETHER  
SULFONE) (S-PEKES) AS PROTON EXCHANGE MEMBRANE (PEM) FOR  
USING IN DIRECT METHANOL FUEL CELL (DMFC)**

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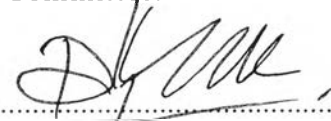
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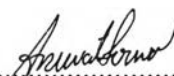
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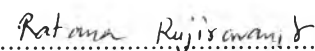
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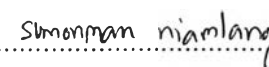
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## ABSTRACT

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Sairung Changkhamchom: Development of Sulfonated Poly(ether ketone ether sulfone) (S-PEKES) as Proton Exchange Membrane (PEM) for Using in Direct Methanol Fuel Cell (DMFC)

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Keywords: Sulfonated poly(ether ketone ether sulfone)/ Proton exchange membrane/ Degree of sulfonation/ Proton conductivity

Poly(ether ketone ether sulfone) (PEKES), was synthesized by nucleophilic aromatic substitution polycondensation between bisphenol S and 4,4'-difluorobenzophenone (system A), and between bisphenol S and 4,4'-dichlorobenzophenone (system B). Properties of both post-sulfonated polymers are compared with those of a commercial PEEK 150XF from Victrex and Nafion 117. Advantages of the synthesized PEKES is the better solubility of PEKES in  $H_2SO_4$  relative to PEEK 150XF which results in higher sulfonation degrees, the carbonyl groups ( $-C=O$ ) and the sulfone groups ( $-SO_2-$ ) in polymer backbone, which promote the chain stiffness and thermal stability. The sulfonated polymer samples were characterized by FTIR,  $^1H$ -NMR, TGA, and LCR meter, and the degree of sulfonation (DS) was determined. The ion exchange capacity (IEC), the water uptake (%), the dielectric permittivity ( $\epsilon'$ ), and the electrical conductivity increase monotonically with increasing DS. The proton conductivity values of S-PEKES of the highest DS are comparable with that of Nafion 117. The methanol, mechanical and oxidative stabilities of S-PEKES and S-PEEK 150XF membranes are relatively higher than those of Nafion 117. Furthermore, the composite proton exchange membranes based on S-PEKES incorporated various types of zeolite such as molecular sieve 3A, 4A, 5A, and ZSM-5 were developed for using as proton exchange membrane.

## บทคัดย่อ

สายรุ้ง แฉ่งจำโหม : การพัฒนาพอลิอีเทอร์คีโตนอีเทอร์ซัลโฟเนที่ผ่านกระบวนการซัลโฟเนชันแล้วเพื่อเป็นเยื่อแลกเปลี่ยนโปรตอนสำหรับใช้งานในเซลล์เชื้อเพลิงแบบเมทานอลโดยตรง (Development of Sulfonated Poly(ether ketone ether sulfone) (S-PEKES) as Proton Exchange Membrane (PEM) for using in Direct Methanol Fuel Cell (DMFC))  
 อ. ที่ปรึกษา : ศ. ดร. อนุวัฒน์ ศิริวัฒน์ 149 หน้า

พอลิอีเทอร์คีโตนอีเทอร์ซัลโฟเน (PEKES) ได้ถูกสังเคราะห์ขึ้นจากปฏิกิริยา nucleophilic aromatic substitution polycondensation ระหว่าง bisphenol S และ 4,4'-difluorobenzophenone (ระบบ A) และระหว่าง bisphenol S และ 4,4'-dichlorobenzophenone (ระบบ B) คุณสมบัติของพอลิเมอร์ภายหลังทำปฏิกิริยาซัลโฟเนชันแล้วจะถูกวิเคราะห์เปรียบเทียบกับพอลิอีเทอร์อีเทอร์คีโตน (PEEK 150XF) และแนฟิออน (Nafion 117) ที่มีขายในท้องตลาด คุณสมบัติของ PEKES ที่เหนือกว่า PEEK 150XF คือสามารถละลายในกรดซัลฟิวริกได้ดีกว่า ซึ่งทำให้หมู่ซัลโฟนิคเข้าไปติดที่สายโซ่พอลิเมอร์ได้ง่ายและเพิ่มขึ้น หมู่คาร์บอนิลและซัลโฟเนที่อยู่ในสายโซ่พอลิเมอร์จะทำให้สายโซ่พอลิเมอร์มีความแข็งและมีความเสถียรต่อเชิงความร้อน พอลิเมอร์ที่ผ่านกระบวนการซัลโฟเนชันแล้วจะถูกวิเคราะห์ด้วยเทคนิค FTIR, <sup>1</sup>H-NMR, TGA, และ LCR meter ระดับการยึดติดของหมู่ซัลโฟนิค (Degree of sulfonation, DS) และค่าการแลกเปลี่ยนไอออน (Ion Exchange Capacity, IEC) และค่าการดูดซับน้ำ (Water uptake %) และค่า dielectric permittivity ( $\epsilon'$ ) มีค่าเพิ่มขึ้นเมื่อจำนวนหมู่ซัลโฟนิคที่ยึดเกาะสายโซ่มีมากขึ้น ค่าการนำโปรตอนของ SPEKES ที่มีค่า DS สูงสุดมีค่าใกล้เคียงกันกับค่าของ Nafion 117 ส่วนค่าความทนทานต่อเมทานอล เสถียรภาพเชิงกลและเชิงความร้อนก็มีค่าสูงกว่า Nafion 117 อีกด้วย นอกจากนี้ในงานวิจัยของเราได้มีการพัฒนาคอมพอสิตเมมเบรนจาก S-PEKES ที่ทำการเติมสารซีโอไลต์หลายชนิด เช่น molecular sieve 3A, 4A, 5A และ ZSM-5 เพื่อนำมาเป็นเยื่อแลกเปลี่ยนโปรตอนด้วย

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