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A Study on Elongation/Contraction Behavior and Mechanical Properties of Oxy-Polyacrylonitrile(PAN) Fiber in Basic/Acidic Solution for Artificial Muscle Applications

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: PAN 가 oxy - PAN
 (NaOH)
 30% (HCl) 30 50%
 , oxy - PAN 가
 . NaOH HCl oxy - PAN
 가
 oxy - PAN
 . Oxy - PAN 가
 가 , oxy - PAN 가
 가

ABSTRACT : Oxy - PAN fiber prepared from the preoxidation and saponification of raw PAN fiber is known to elongate and contract when immersed in basic and acidic solutions, respectively. In this study, about 30% elongation in NaOH solution and 30 50% contraction in HCl solution have been observed. In mechanical test, the mechanical properties of oxy - PAN fiber in the contracted state was stronger than that in the elongated state. These behaviors and mechanical properties are compared to those of living muscle and linear actuator. The change of length in NaOH and HCl solutions is due to switching between a hydrophilic and a hydrophobic structure. Other reasons are exchange of ion and water in/out of oxy - PAN fiber, and osmotic pressure difference associated with relevant ions. Much studies are needed to clarify the effective factors on but the oxy - PAN fiber's elongation/contraction behavior and mechanical properties, but the oxy - PAN fiber prepared in our laboratory has a sufficient potential for application as artificial muscle and linear actuator.

Keywords : oxy-PAN fiber, elongation, contraction, artificial muscle, linear actuator.

20 가

1970

가 1,2

가 3,4

(drug delivery system)

pH, 가

1000

가

가 Poly-acrylamide(PAM), poly(vinyl alcohol) - poly (acrylic acid), poly(2-acrylamide-2-methylpropane) sulfonic acid

7-10 polyacrylonitrile(PAN)

PAN 가

/ /

가 . PAN

가

PAN

, S. Umemoto가¹¹

PAN 220 250

가

oxy - PAN

oxy - PAN

12,13

NaOH HCl oxy - PAN 가

Schreyer¹⁴

. Figure 1

NaOH , oxy - PAN 가

(OH⁻) 가

-COO⁻ 가

HCl

(H⁺) 가

oxy - PAN 가

PAN

oxy -

15

Oxy - PAN

NaOH oxy - PAN 가

가 가

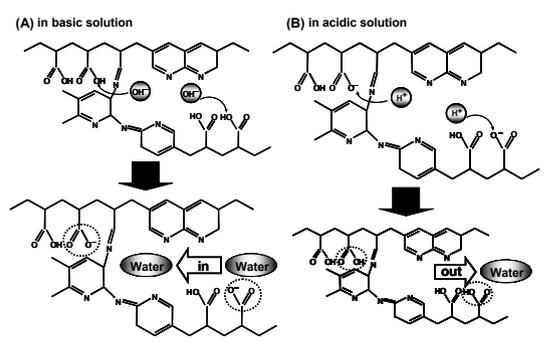


Figure 1. The mechanism for elongation and contraction behavior of oxy - PAN fiber in basic and acidic solutions. Oxy - PAN elongates when exposed to hydroxyl ion(OH⁻) in solution and contracts when exposed to proton(H⁺) in acidic solution.¹⁵

oxy - PAN 가 가 HCl 가 가 가 (Sometech vision, Korea) 0.5 N HCl 가 , oxy - PAN (1)

가 1.0 N 2.0 N 가 Oxy - PAN 가 Change of State (%) = $\frac{\text{Final state} - \text{Initial state}}{\text{Initial state}} \times 100$ (1)

, oxy - PAN 가 NaOH HCl Oxy-PAN Oxy - PAN NaOH HCl oxy - PAN 가 oxy - PAN

Oxy-PAN PAN oxy - PAN 가 (: 200 μm, 1,000 (6 μm)) oxy - PAN Oxy - PAN 가 , PAN ^{16,17} , PAN 가 2 240 Oxy-PAN PAN 가 , oxy - PAN 1.0 N NaOH 100 30 , PAN 가 oxy - PAN 2 , NaOH (Na⁺) 가 가 PAN . Oxy - PAN

NaOH HCl Oxy-PAN NaOH PAN ¹¹ Figure 2 HCl 0.5, 1.0, 2.0 N NaOH HCl oxy - PAN NaOH HCl NaOH HCl Oxy - PAN NaOH HCl oxy - PAN 5 Table 1 oxy - PAN HCl NaOH , 가 oxy - PAN HCl 5 , HCl oxy - PAN 가

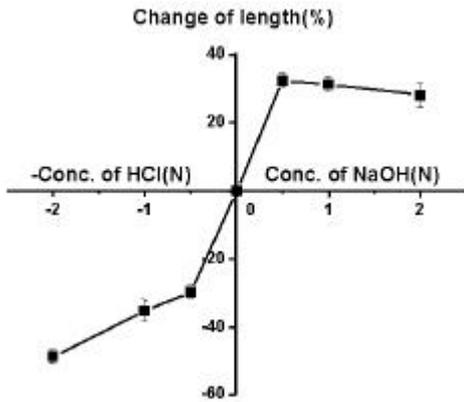


Figure 4. Change of length for the elongated and contracted oxy - PAN fiber in NaOH and HCl solutions.

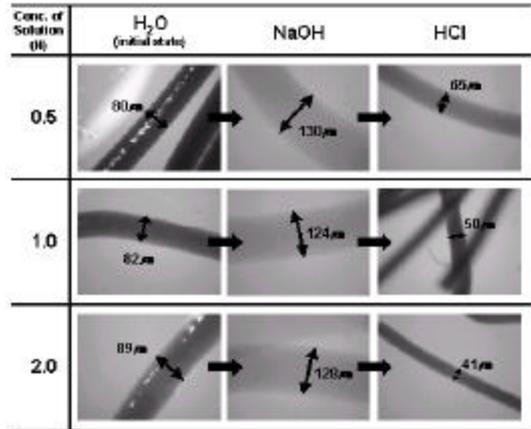


Figure 5. Optical micrographs of monofilament when oxy - PAN fiber was immersed in NaOH and HCl solutions, respectively(× 800).

Figure 4
 , NaOH 가 가 oxy - PAN
 가 가 가
 가 가 , NaOH
 가 가 oxy - PAN
 , 가
 NaOH HCl oxy - PAN
 가

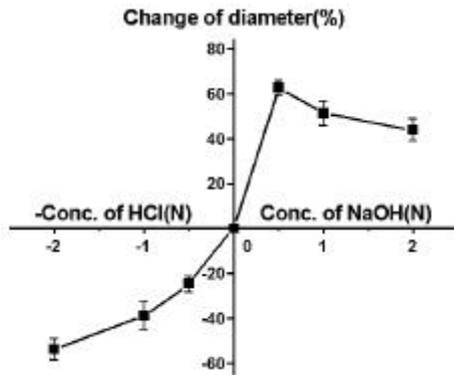


Figure 6. Change of diameter for the elongated and contracted oxy - PAN fiber in NaOH and HCl solutions.

Figure 5
 가
 1.5 3.0%
 NaOH 가
 가 , HCl 가
 , NaOH
 Oxy - PAN

Figure 6
 가 가
 가 HCl 가 가
 oxy - PAN
 Table 1
 , NaOH
 , oxy - PAN
 가 가
 . Oxy - PAN

/ /
 (0.5 N) oxy - PAN
 가 가
 NaOH 가 . , oxy - PAN
 HCl . oxy - PAN
 PAN , . HCl oxy - PAN
 , NaOH 가 , oxy - PAN 가
 (Na⁺) HCl
 (Cl⁻) , oxy - PAN 가
 가 가
 . NaOH 가 가 , oxy - PAN
 가
 . Donnan 18 가 가 , oxy - PAN HCl
 가 가
 . Figure 7 NaOH HCl oxy -
 PAN NaOH HCl Oxy-PAN
 NaOH HCl oxy - PAN
 가 Table 1
 oxy - PAN , oxy - PAN
 (Na⁺) 가 가 Figure 8
 Oxy - PAN
 가 . Oxy - PAN 가
 oxy - PAN 가
 oxy - PAN
 NaOH oxy - PAN 가
 가 가
 가 (Figure 8 A, B, C).
 , 0.5 N NaOH oxy - PAN 가 가
 가 , 2.0 N
 NaOH 가
 . Figure 4 , HCl
 oxy - PAN 가 가

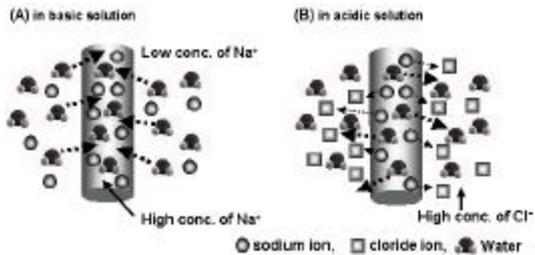


Figure 7. The exchange of ions and water in/out of oxy - PAN fiber in (A) NaOH and (B) HCl solution.

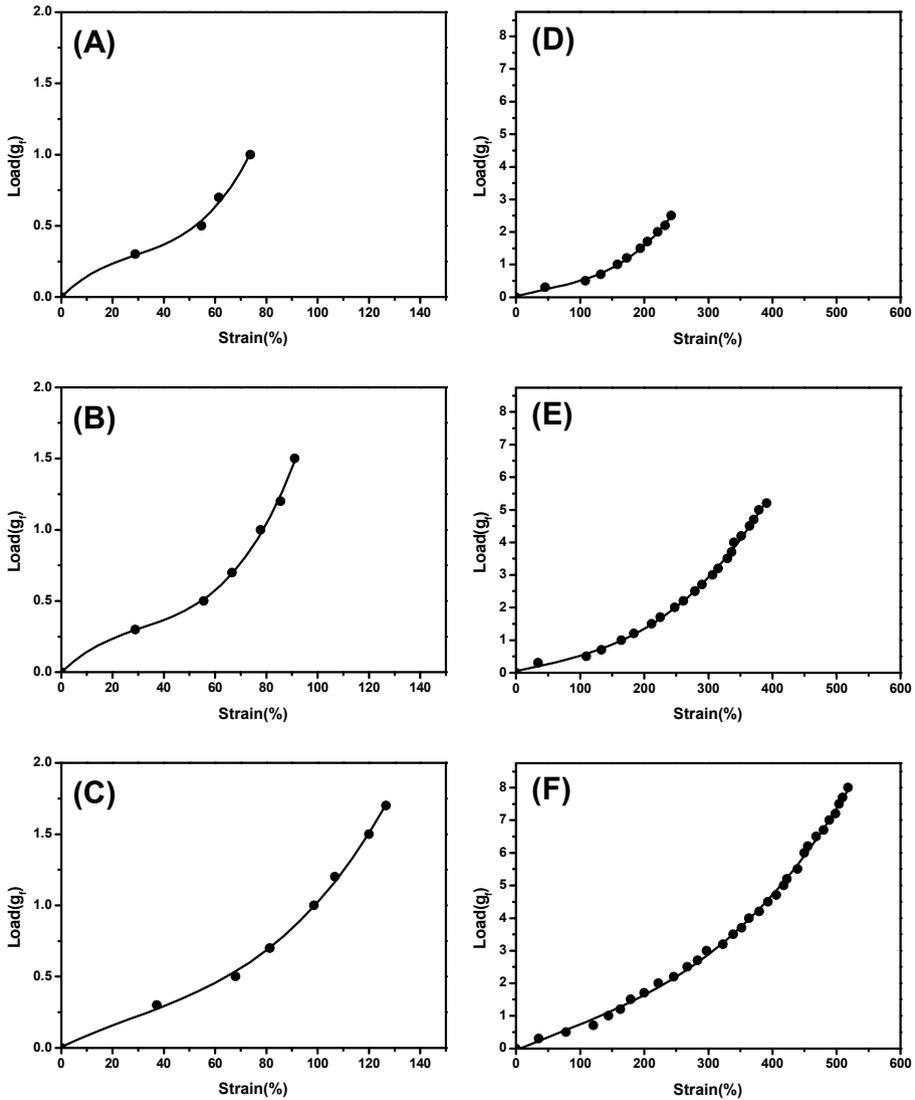


Figure 8. Load - Strain Relationship for the elongated and contracted oxy - PAN fiber in (A) 0.5 N NaOH, (B) 1.0 N NaOH, (C) 2.0 N NaOH, (D) 0.5 N HCl (E) 1.0 N HCl, and (F) 2.0 N HCl solution.

가 HCl 가
 (Figure 8 D, E, F). 0.5 N HCl 가 가 가
 가 1.0 N 2.0 N 가 , NaOH HCl
 가
 Figure 9 oxy - PAN
 . NaOH 가
 가 oxy -

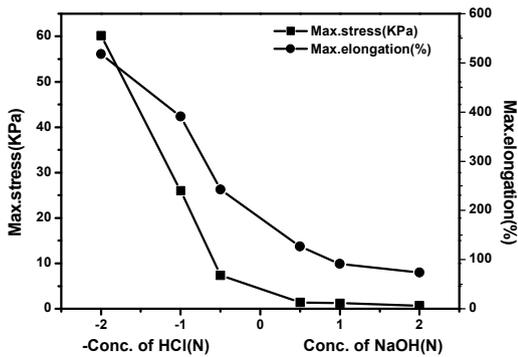


Figure 9. Maximum load and elongation for the elongated and contracted oxy - PAN fiber in NaOH and HCl solutions.

PAN 가 가 , oxy - PAN
 19
 가 oxy - PAN
 . NaOH
 , HCl
 oxy - PAN
 가
 가
 HCl 가 가
 가 oxy - PAN
 가
 , HCl oxy - PAN 가 NaOH
 가 HCl 가 가
 가
 30%
 oxy - PAN
 . PAN
 가
 19
 oxy - PAN 가
 가
 가 oxy - PAN 가
 가

/ /
 .
 PAN 가
 oxy - PAN
 oxy - PAN
 28 32% 30
 48%
 가
 oxy - PAN 가
 oxy - PAN 가
 3
 가
 가

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