IOCG 2025 Conference
The 1st International Online Conference on Gels
03–05 December 2025 | Online
MDPI

Preparation of elastic PVA/PAAm double-network hydrogel for application in artificial blood vessel materials

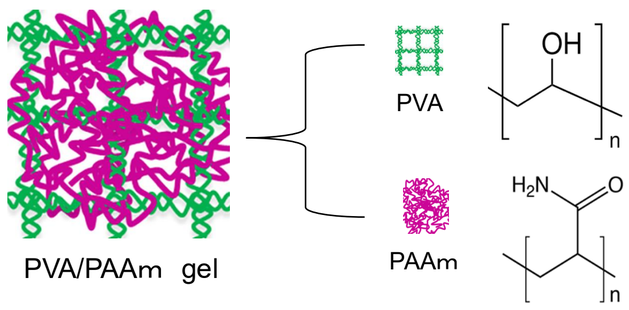
Akemi Nagao[1], Masatoshi Iriki-in[1], Kenta Tanaka[1], Masakazu Muto[2], Kazuya U. Kobayashi[1]
[1] Nippon Institute of Technology, [2] Nagoya Institute of Technology

INTRODUCTION & AIM

Polyvinyl alcohol hydrogels (PVA-H) have attracted considerable attention for use in a wide range of fields owing to their high water content, excellent biocompatibility, and ease of processing. Representative applications include medical and biomedical fields (e.g., artificial blood vessels and drug-delivery systems) [1] and industrial applications in the environmental sector (e.g., sensors and electronic devices) [2].

For applications such as artificial blood vessels and the visualization of stress interactions at the blood-vessel interface, the following material properties are required:

- **high transparency**
- **high mechanical strength**
- **mechanical flexibility**



PVA/PAAm hydrogels were prepared using three simple methods — **crushing**, **swelling**, and **mixing** — and their mechanical properties were evaluated for potential use as artificial blood vessels. In addition, their transparency was assessed to determine their suitability for photoelastic measurements.

REAGENT & METHOD

Solvent
A mixed solvent of pure water and DMSO (dimethyl sulfoxide) at a mass ratio of 2:8

Monomer
PVA (polyvinyl alcohol)
- concentration (5 wt%, 7.5 wt%, 10 wt%)

AAm (acrylamide)
- concentration (5 wt%, 10 wt%, 15 wt%)

Crosslinker
MBAA (N,N′-methylenebisacrylamide)

Initiator
OA (2-oxoglutaric acid)

(a) crushing

① A solution of pure water/DMSO (2:8) and up to 5 wt% PVA was stirred at 100 ℃ for 1 hour.
② The solution was frozen at - 40 ℃ for 18 hours to obtain a PVA gel. The resulting gel was then finely crushed at room temperature.
③ AAm, MBAA (0.1 wt%), and OA (0.05 wt%) were dissolved in pure water at room temperature, then added the crushed PVA gel from step ② and stirred thoroughly.
④ ③ was cast into a cubic mold, degassed under vacuum, and then irradiated with UV light (365 nm).

(b) swelling

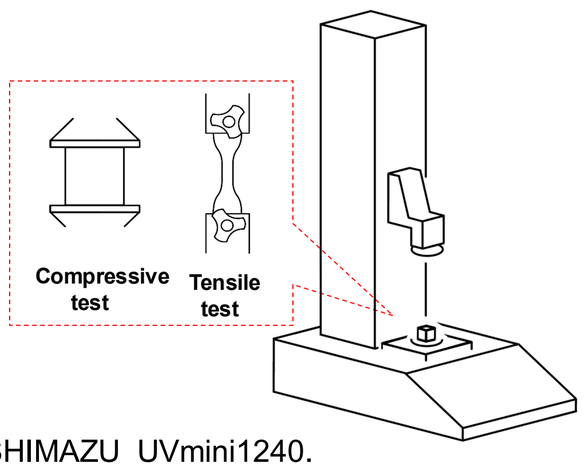
① A solution of pure water/DMSO (2:8) and PVA was stirred at 100 ℃ for 1 hour.
② The solution was cast into a cubic mold and was frozen at - 40 ℃ for 18 hours. PVA gel was obtained after thawing
③ AAm, MBAA (0.1 wt%), and OA (0.05 wt%) were dissolved in pure water at room temperature.
④ The PVA gel was placed into ③ and swelled the AAm solusion.
⑤ The swollen PVA gel was irradiated with UV light (365 nm).

(c) mixing

① A solution of pure water/DMSO (2:8) and PVA was stirred at 100 ℃ for 1 hour.
② AAm, MBAA (0.1 wt%), and OA (0.05 wt%) were dissolved in pure water at room temperature.
③ ① and ② were mixed, then stir thoroughly at room temperature.
④ ③ was cast into a cubic mold, degassed under vacuum, and then irradiated with UV light (365 nm).

◆ mechanical characterization

- **compression test**
  size : 25 mm × 25 mm × 25 mm
  compression rate : 30 mm/min
- **tensile test**
  shape : dumbbell-shaped
  (in accordance with JIS K 6521)
  crosshead speed : 50 mm/min



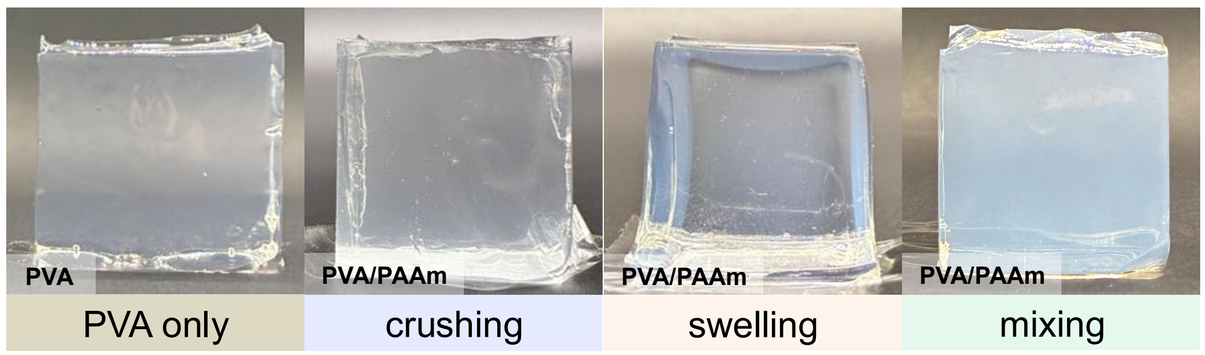
◆ optical transparency evaluation

Visible light transmittance was measured by SHIMAZU UVmini1240.
- Wavelength range : 380~780 nm

RESULTS & DISCUSSION

◆Comparison of gels by preparation method

method	transparency	formability	concentration control
crushing	◎	○	×
swelling	○	△	△
mixing	○	◎	◎



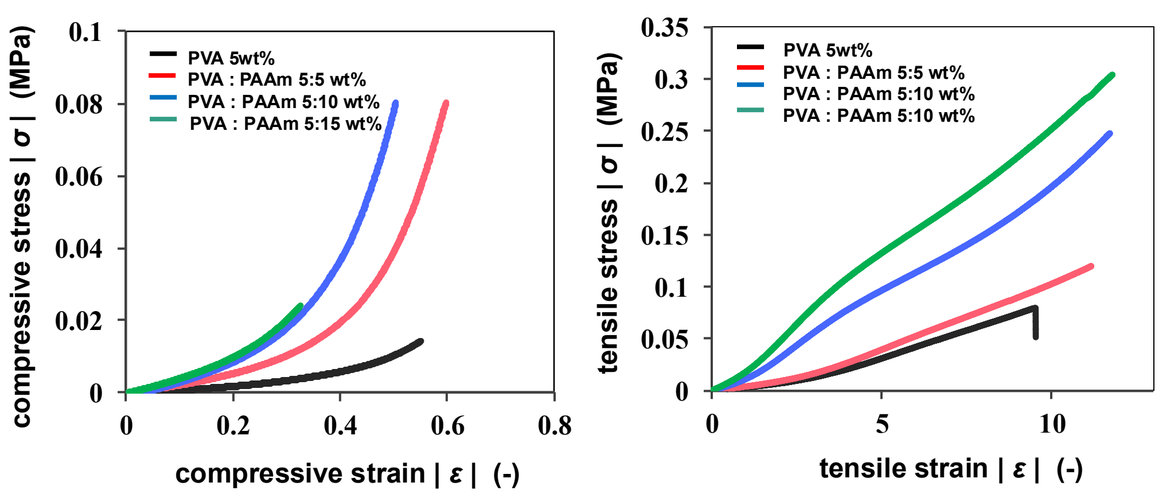
Among the three methods, the **mixing method** showed the most favorable properties and was therefore selected for further use.

◆ Young's modulus (MPa) of the mixing methods

PVA (wt%)	PAAm 0 wt%	PAAm 5 wt%	PAAm 10 wt%	PAAm 15 wt%
5	0.0107	0.0291	0.0336	0.0414
7.5	0.0213	0.0670	0.0795	0.1295
10	0.0534	0.1233	0.1599	0.3342

The Young's modulus was confirmed to satisfy the requirements for artificial blood vessel applications.

◆ stress-strain curve



By increasing the PAAm concentration, the mechanical strength of the PVA/PAAm gel can be enhanced.

◆ optical transparency

A transmittance of 54.58% at 550 nm was achieved even for the most opaque sample, indicating that the material is suitable for photoelastic measurements.

CONCLUSION

- Gels prepared by the crushing and swelling methods exhibited high transparency; however, limited control over the PVA and AAm concentrations restricted further enhancement of their mechanical strength.
- The gel prepared by the mixing method allowed facile control of concentrations and achieved high mechanical strength, while maintaining transparency within the acceptable range for photoelastic measurements.

Reference

[1] Y. Zhang, M. Song, Y. Diao, B. Li, L. Shi, and R. Ran, *RSC advances* **6**,113 (2016).
[2] Y. Yang, T. Wang, Y. Guo, P. Liu, X. Han, and D. Wu, *Materials Today Chemistry* **29** (2023).