Potassium ion coordination and ionic transport in Alginate–PVA polymer electrolyte

Materials Science and Engineering: B • Article • 2025 • DOI: 10.1016/j.mseb.2025.118644

Wahab N.A. [a]; Saadiah M.A. [b]; Ghazali N.M. [a]; Aoki K. [c]; Nagao Y. [c]; +2 authors

[a] Ionic Materials Team, Faculty of Industrial Sciences & Technology, Universiti Malaysia Pahang Sultan Abdullah, Pahang, Kuantan, 26300, Malaysia

Abstract

Solid biopolymer electrolyte (SBPE) systems based on alginate–polyvinyl alcohol (Al–PVA) doped with varying contents of potassium carbonate (K_2CO_3) were successfully developed using a solution casting technique. Structural analysis via FTIR and XPS confirmed strong interactions between K^+ ions and the functional groups of the biopolymer blend. XRD results revealed reduced crystallinity with salt incorporation, indicating enhanced amorphousness favorable for ion transport. Thermal analysis using TGA and DSC showed improved thermal stability and segmental mobility with increasing K_2CO_3 content. Impedance spectroscopy indicated a notable drop in bulk resistance with optimal conductivity of 1.31×10^{-5} S cm^{-1} achieved at 12 wt% K_2CO_3. Temperature-dependent conductivity obeyed Arrhenius behavior, confirming thermally activated ion conduction. Transport parameters derived using the Arof–Noor model (number of charge carriers, mobility, and diffusion coefficient) exhibited trends consistent with conductivity results. These findings demonstrate the Al–PVA–K_2CO_3 SBPE system's potential for energy-related applications requiring sustainable and thermally stable electrolytes. © 2025

Author keywords

Biopolymer blend; Electrolytes materials; Ion-charge mobility; K^+ ions conduction; Physicochemical properties

Indexed keywords

Engineering controlled terms

Carrier mobility; Crystallinity; Fourier transform infrared spectroscopy; Ion exchange; Ionic conduction; Ions; Physicochemical properties; Solid electrolytes; Thermoanalysis; Thermodynamic stability

Engineering uncontrolled terms

Biopolymer electrolyte; Biopolymers blends; Charge mobilities; Electrolyte material; Electrolyte systems; Ion conduction; Ion-charge; Ion-charge mobility; K+ ion conduction; Physicochemical property

Engineering main heading

Potash

Funding details

Details about financial support for research, including funding sources and grant numbers as provided in academic publications.

Funding sponsor	Funding number	Acronym
Japan Advanced Institute of Science and Technology See opportunities by JAIST		JAIST
Ministry of Higher Education, Malaysia See opportunities by MOHE	FRGS/1/2023/STG05/UMP/02/2	MOHE
Ministry of Higher Education, Malaysia See opportunities by MOHE		MOHE
University Malaysia Pahang Al-Sultan Abdullah	RDU233001	
Association of Southeast Asian Nations See opportunities by ASEAN	Y2024L0906016	ASEAN
Association of Southeast Asian Nations See opportunities by ASEAN		ASEAN

Funding text

The authors would like to thank the Ministry of Higher Education Malaysia (MOHE) under the FRGS fund (FRGS/1/2023/STG05/UMP/02/2) and University Malaysia Pahang Al-Sultan Abdullah (UMPSA) under the UMPSA Distinguish Grant (RDU233001) for funding this research and Japan Advanced Institute of Science and Technology (JAIST), for the help and support given for the completion of this work. In addition, A.S. Samsudin would like thanks Networked Exchange, United Strength for Stronger Partnerships between Japan and ASEAN (NEXUS) program (Y2024L0906016).The authors would also like to thank Ionic Materials Team members, M.A. Saadiah and N.F. Mazuki for kindly help in completing this research.

Corresponding authors

Corresponding author	A.S. Samsudin
Affiliation	Ionic Materials Team, Faculty of Industrial Sciences & Technology, Universiti Malaysia Pahang Sultan Abdullah, Pahang, Kuantan, 26300, Malaysia

Email address ahmadsalihin@umpsa.edu.my