Aluminium foil modification by Piranha Solutions (PS) to control the level of silanes loading

Xiao Chen[a], Joanna Kujawa[a], Marta Głodek[a], Katarzyna Knozowska[a], Wojciech Kujawski[a]*

[a] Nicolaus Copernicus University in Toruń, Faculty of Chemistry, 7 Gagarina Street, 87-100 Toruń, Poland

*Corresponding author: wkujawski@umk.pl; Tel.: +48566114517 (W.K.)

Abstract:

Aluminium foil is one of the material which could be used for the comparison with porous materials in the membrane characterization. Surface roughness and porosity are defined as important factors in enzyme immobilizations of ceramic membranes correlated to the surface area [1, 2]. Therefore, aluminium foil was selected to investigate the modification mechanism with different synthesized silanes on the smooth surface. Modifiers were synthesized for the enzyme immobilization including terminal functionalities as methyl, phenyl, tert-butyl, adamantane, and commercial fluorinate with different length of silanes. To activate the surface of the aluminium for silanes introduction, the hydroxyl functionality was chosen for the first stage modification. Owing to the reactivity of metal under acid and base media, the Piranha method was considered with a concentration of 20% Piranha Solution (PS) which has been previously applied on polymeric and ceramic membranes [3]. 30s, 5 min, 30 min, 60 min, and 120 min in both acid and base PS conditions were investigated for the activation of Al foils. Subsequently, samples were immersed in the dichloromethane (DCM) solution of modifiers for 72 h. The physicochemical properties and surface morphologies were investigated at each stage of the surface modification. Generally, along with the duration increase, the oxygen level under energy dispersive x-ray spectroscopy (EDS) increased continuously to 50 at% under base PS, compared to the pristine material which was also confirmed by using Fourier transform infrared spectroscopy (FTIR). The morphology changed to honeycomb or pores-like surface features after activation and they covered by silanes after modification from scanning electron microscopy images (SEMs) - Figure 1. The surface of foil also changed to hydrophilic one which is in an agreement with EDS and FTIR measurements (Figure 1B and C). The -OH amount grafted on aluminium was estimated from thermogravimetric analysis (TGA) and reached 1.84×10^{-4} mol/g after the 60 min base PS activation. Furthermore, the modification resulted in the increase of fluorine content up to 17 at% and contact angle increased to 132° from 17° before the modification of the foil after base PS 60 min activation. Thus, this successful modification can be applied to the comparison of the enzyme immobilization on ceramic materials for further understanding of the grafting efficiency.

Keywords: Surface modification, Organic modifiers, Silanization, Aluminium

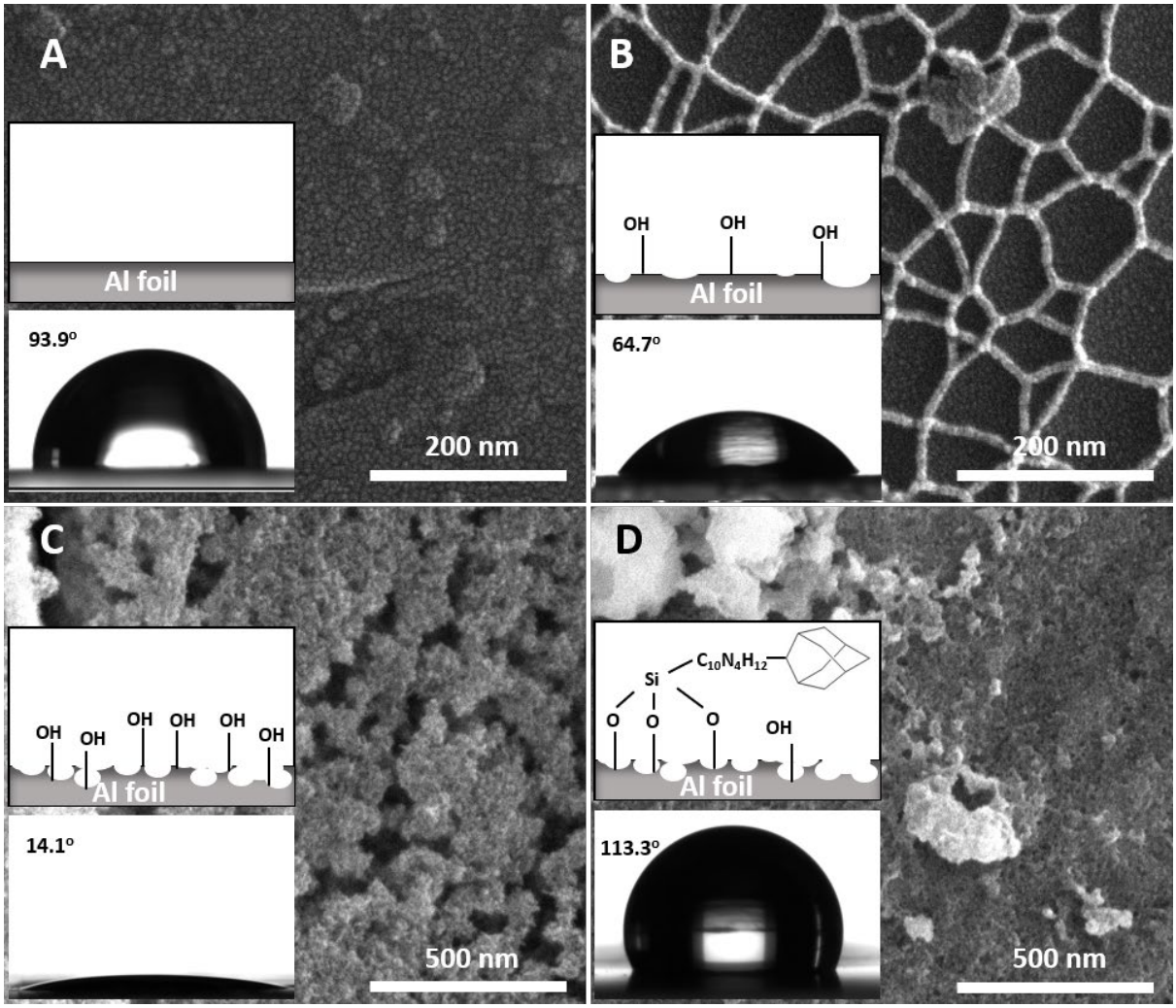

Figure 1. SEM images and contact angles with potential mechanism of modifications for modified aluminium surface. A) Pristine; B) Acid PS treated 120 min; C) Base PS treated 120 min; D) Base PS treated 120 min and modified with adamantane functionalized silanes

Reference

[1] Kujawa J, Głodek M, Li G, Al-Gharabli S, Knozowska K, Kujawski W. Highly effective enzymes immobilization on ceramics: Requirements for supports and enzymes. Science of The Total Environment. 2021;801:149647.
[2] Kujawa J, Głodek M, Koter I, Li G, Knozowska K, Kujawski W. Bioconjugation Strategy for Ceramic Membranes Decorated with Candida Antarctica Lipase B—Impact of Immobilization Process on Material Features. Materials. 2022;15.
[3] Al-Gharabli S, Kujawski W, El-Rub ZA, Hamad EM, Kujawa J. Enhancing membrane performance in removal of hazardous VOCs from water by modified fluorinated PVDF porous material. Journal of Membrane Science. 2018;556:214-26.