Analysis of The Morphological And Mechanical Characterization of Aluminium Matrix Composite Reinforced With Chitosan

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Introduction

Motivation

Aluminium Matrix Composites is a widely used material for construction, manufacturing and domestic use. However, current manufacturing methods involve the use of unsustainable techniques or materials. In this study, we re-purpose agricultural waste as a composite reinforcement material in an Eco-friendly manner.

- Cost
- Environmental Effects {Preparing Ash, Extracting SiO_2}
- Improved Performance
  - Hardness {Turbine Blades}
  - Tensile Strength {Pistons}
  - Electric Conductivity {Electric cables}
  - Thermal Conductivity {Cooking pots}
  - Corrosion Resistance {Tubing and pipes}

Synthetic Ceramic Composites

Material	Authors	Improvements
AC-44200 + Al_2O_3	[Kurzawa et al., 2018]	Ballistic resistance by up to 60 % reduction in projectile velocity.
AA6061 + TiC	[Kareem et al., 2021]	improved wear resistance
Al-alloy + SiC	[Zakaria, 2014]	increased tensile and hardness
Aluminium Alloy + TiC	[Reddy et al., 2018]	increased compressive strength
Aluminium Alloy + ZrB_2	[Sivakumar et al., 2019]	increased compressive strength and reduced wear volume

Biodegradable reinforcement materials

Material	Authors	Improvements
Al-Matrix + Wood particles	[Omoniyi et al., 2021]	improved UTS and mechanical properties.
AA2014 + Egg Shells	[Dwivedi et al., 2016]	improved hardness
Aluminium Alloy + Rish Husk Ash	[Singh, 2018]	improved wear resistance
$Al - 4.5\%Cu +$ Bamboo Leaf Ash	[Kumar et al., 2018]	increased yield strength
A356 + alloy + Breadfruit Seed Ash	[Atuanya et al., 2014]	decreased wear rate

Hybrid Reinforcements

Material	Authors	Improvements
AA7075 + B_4C + MoS_2	[Liu et al., 2019]	decreased abrasive wear and increased tensile strength.
AA6082 + Gr + Y_2O_3	[Kumar et al., 2020]	reduced wear rate and friction coefficient
AA3003 + CNT + TiC	[Nayim et al., 2020]	increased hardness
AA6061 + SiC + Al_2O_3	[Umanath et al., 2014]	increased microhardness

Materials

- Aluminium Alloy : AA6061
  - Aluminium 6061 is a magnesium-silicate alloy with minor iron, copper, chromium, zinc, tin, and manganese. Silicon and magnesium are the primary alloying constituents of aluminium, AA 6061. The material is desired for its features, such as high strength and weld-ability.
- Chitosan
  - Chitosan is a bio-polymer responsible for strength in bones, teeth, and scales of crustaceans.
  - It has appealing properties like high thermal conductivity, high tensile and hardness strength.
  - Chitosan possesses bio-genic antibacterial properties.
  - Sustainable source of reinforcement material gotten from *Micropogonias undulatus* scales

Filtering and Stir-Casting + Thermal treatment

Figure 1: Powdered Chitosan at 90 μm and Fabricated Composites

Experiments

- Thermal Tests
  - Thermal Conductivity
- Mechanical Tests
  - Hardness
  - % Elongation
  - Tensile Strength
- Micro-structural Tests
  - Hardness
  - X-ray Diffractometer
  - Scanning Electron Microscope
  - Energy Dispersion Micrography
- Electrical Tests
  - Conductivity

Thermal properties

Sample	Heat Transfer Coefficient (W/mK)
AA6061	362.97
AA6061 + 3 wt. % Chitosan	141.59
AA6061 + 6 wt. % Chitosan	189.40
AA6061 + 9 wt. % Chitosan	141.59
AA6061 + 12 wt. % Chitosan	124.16

Hardness

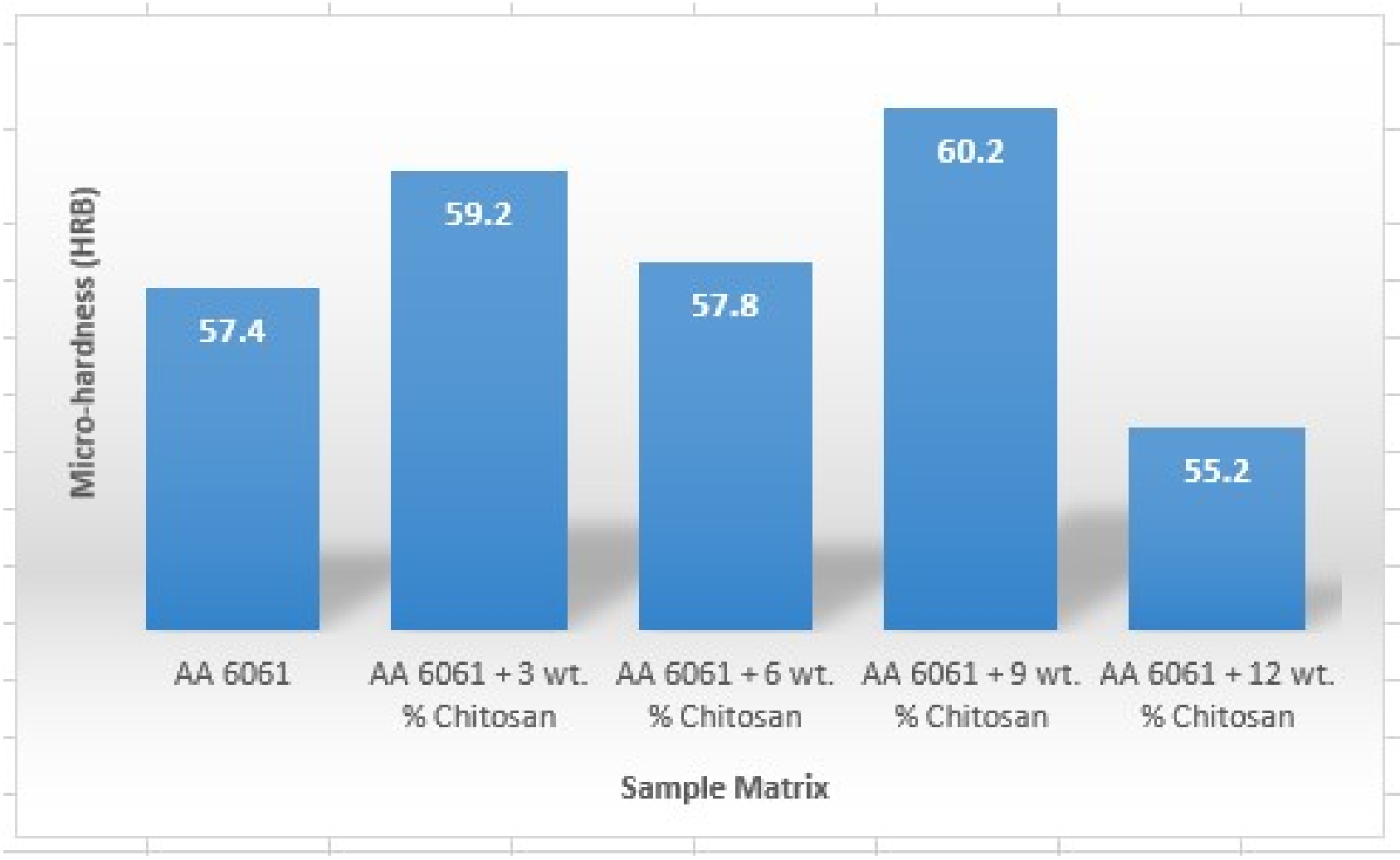

Figure 2: Hardness of Fabricated Aluminium Matrix Composites

% Elongation

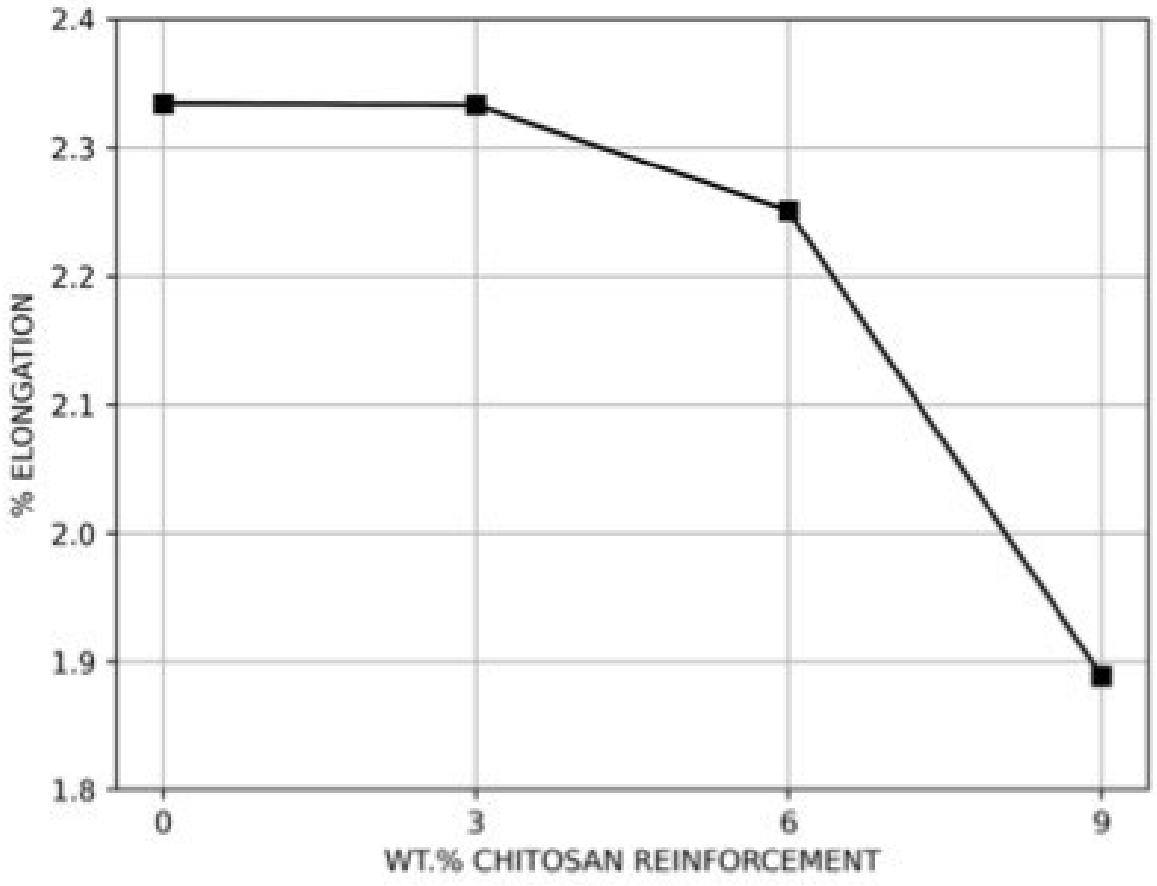

Figure 3: % Elongation of Fabricated Aluminium Matrix Composites

Tensile Strength

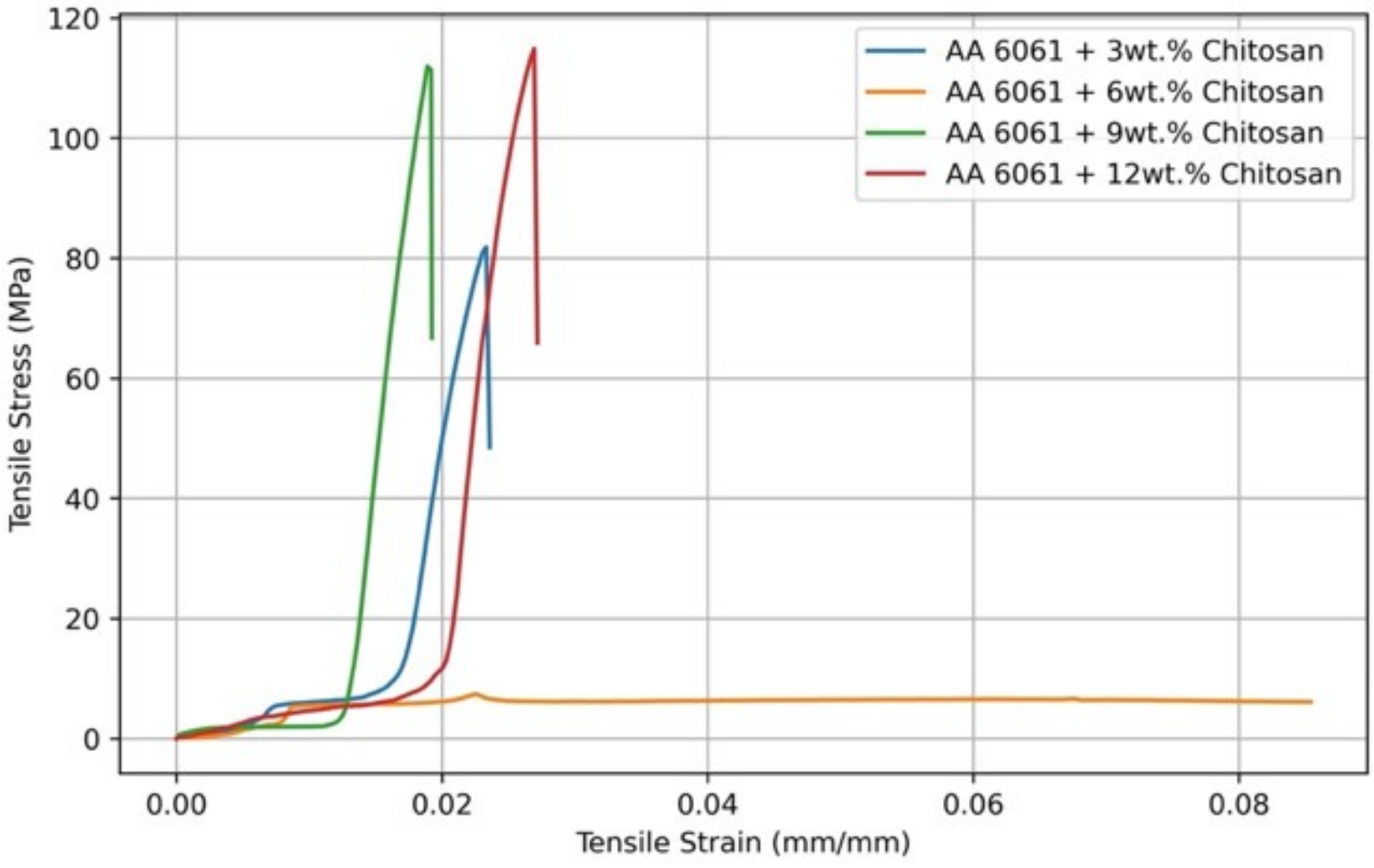

Figure 4: Tensile Strength of Fabricated Aluminium Matrix Composites

X-ray Diffractogram

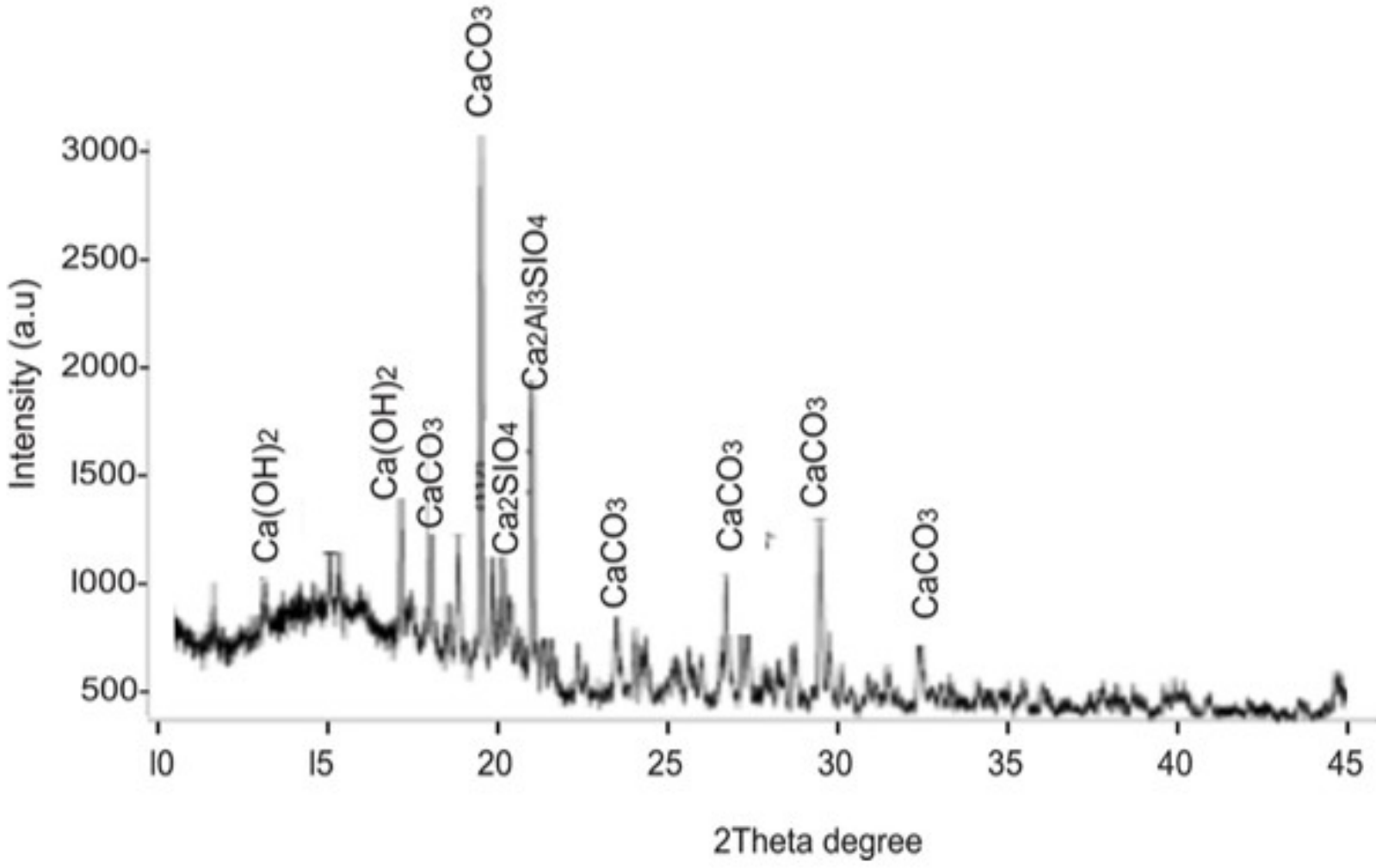

Figure 5: XRD AA6061

X-ray Diffractogram | 3 wt % Chitosan

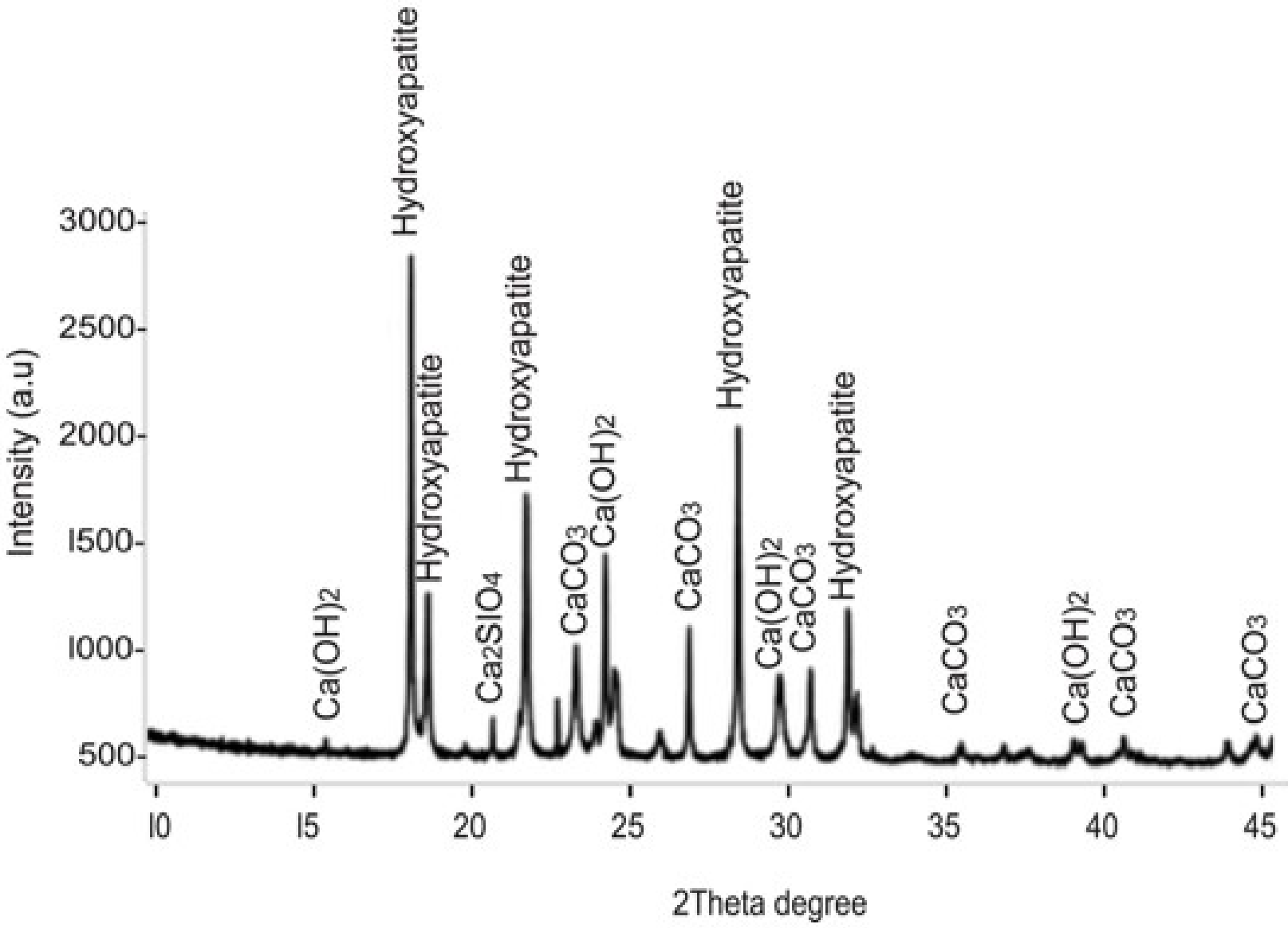

Figure 6: XRD AA6061 + 3 wt % Chitosan

X-ray Diffractogram | 6 wt % Chitosan

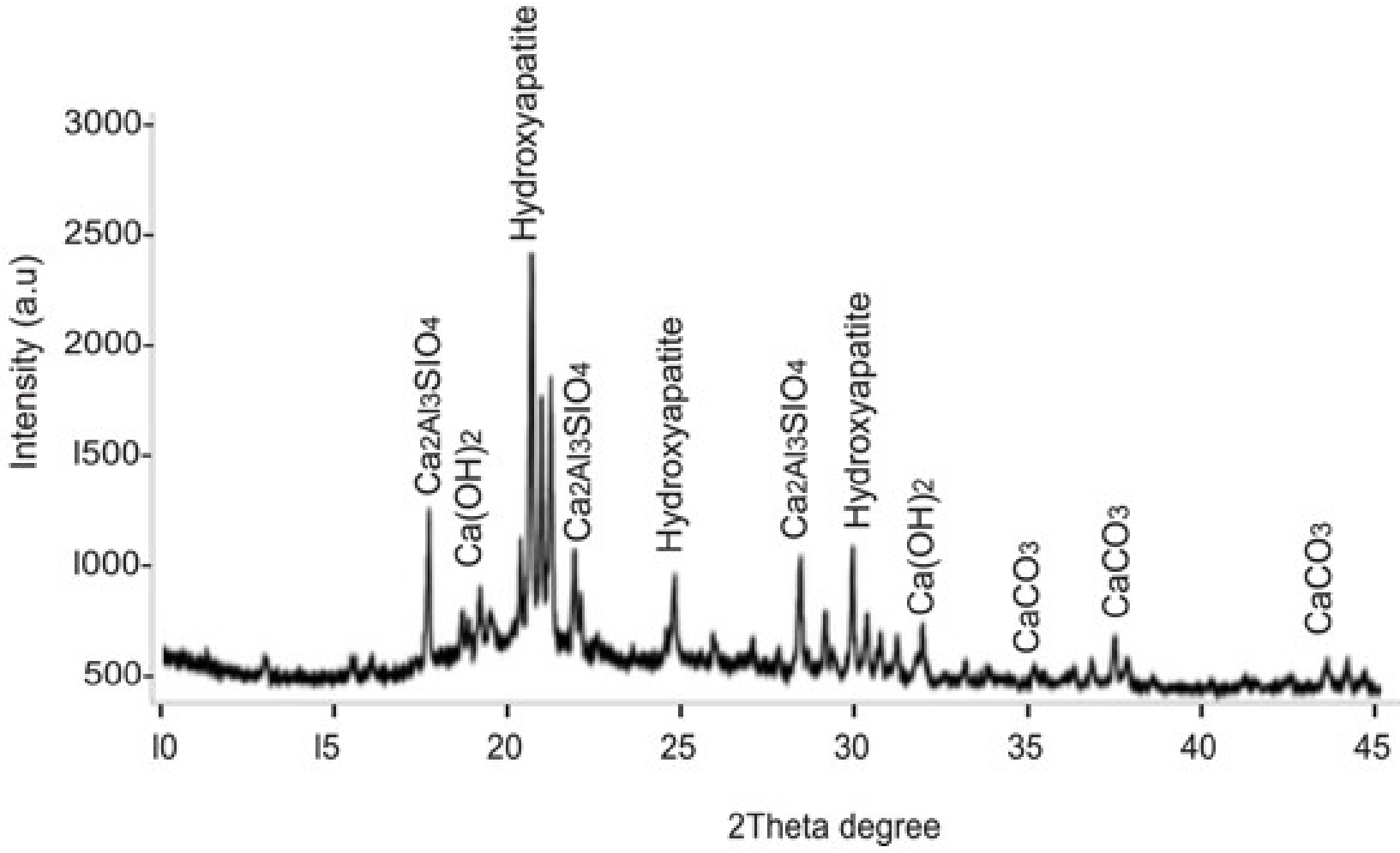

Figure 7: XRD AA6061 + 6 wt % Chitosan

X-ray Diffractogram | 9 wt % Chitosan

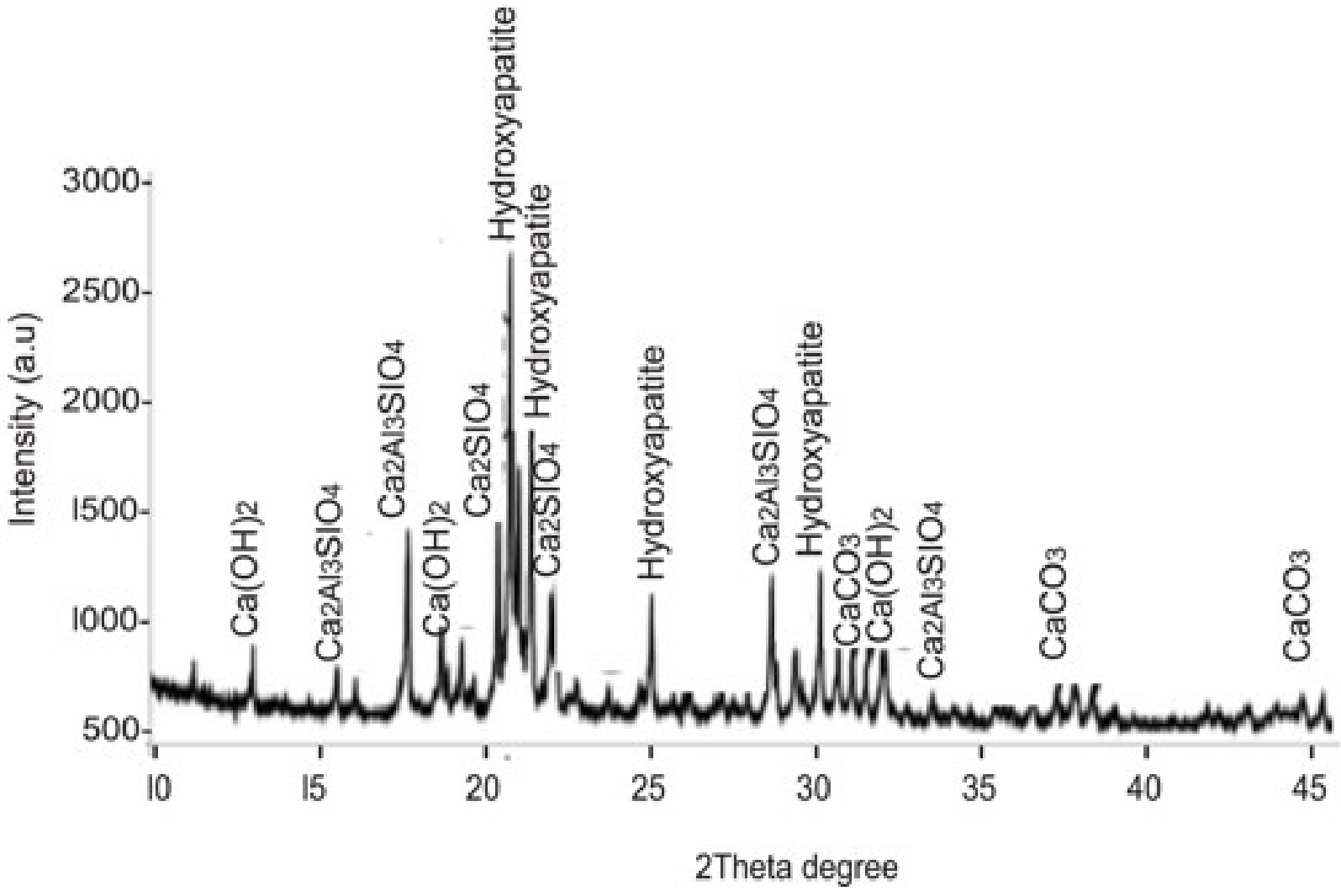

Figure 8: XRD AA6061 + 9 wt % Chitosan

X-ray Diffractogram | 12 wt % Chitosan

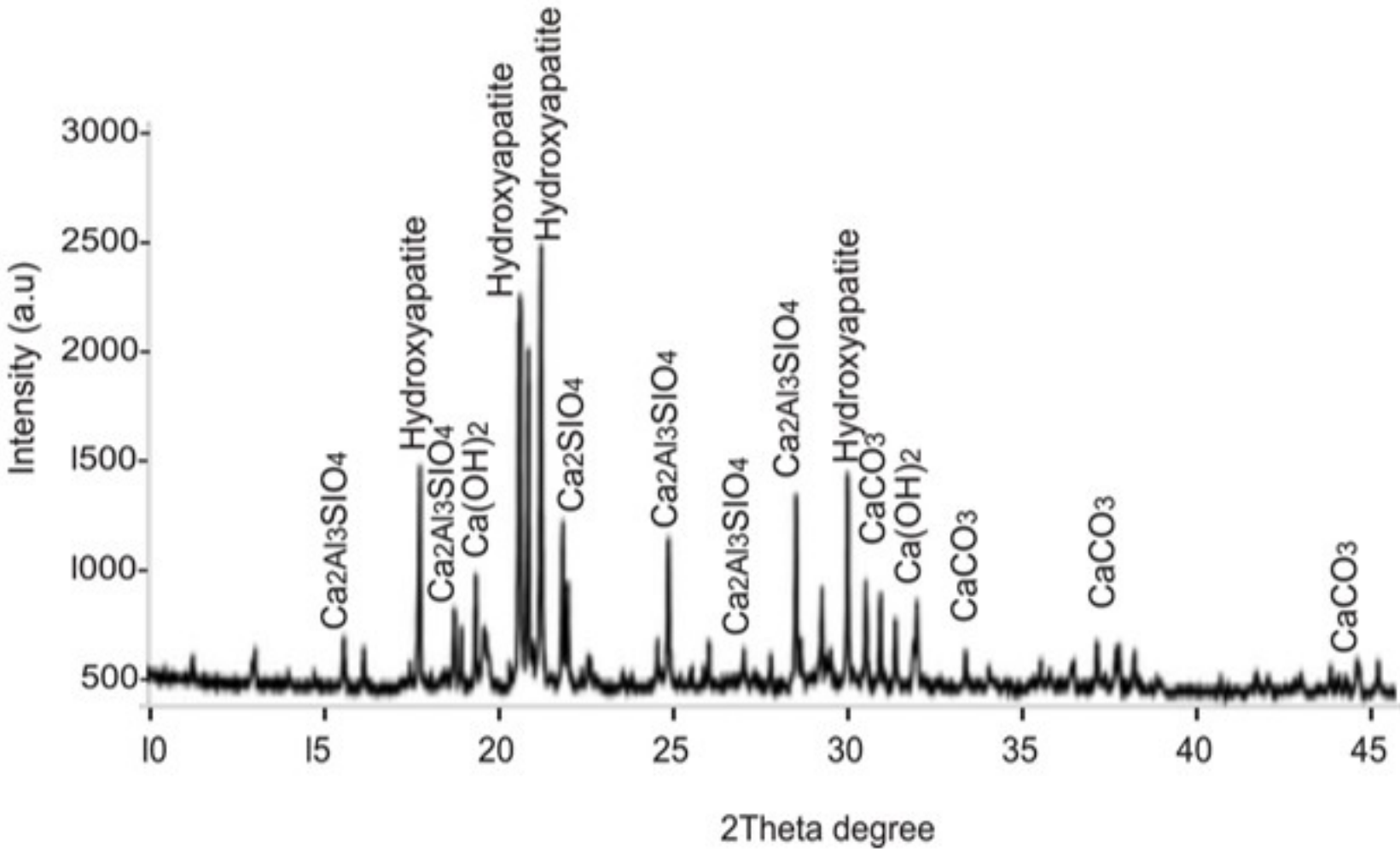

Figure 9: XRD AA6061 + 12 wt % Chitosan

Scanning Electron Microscope

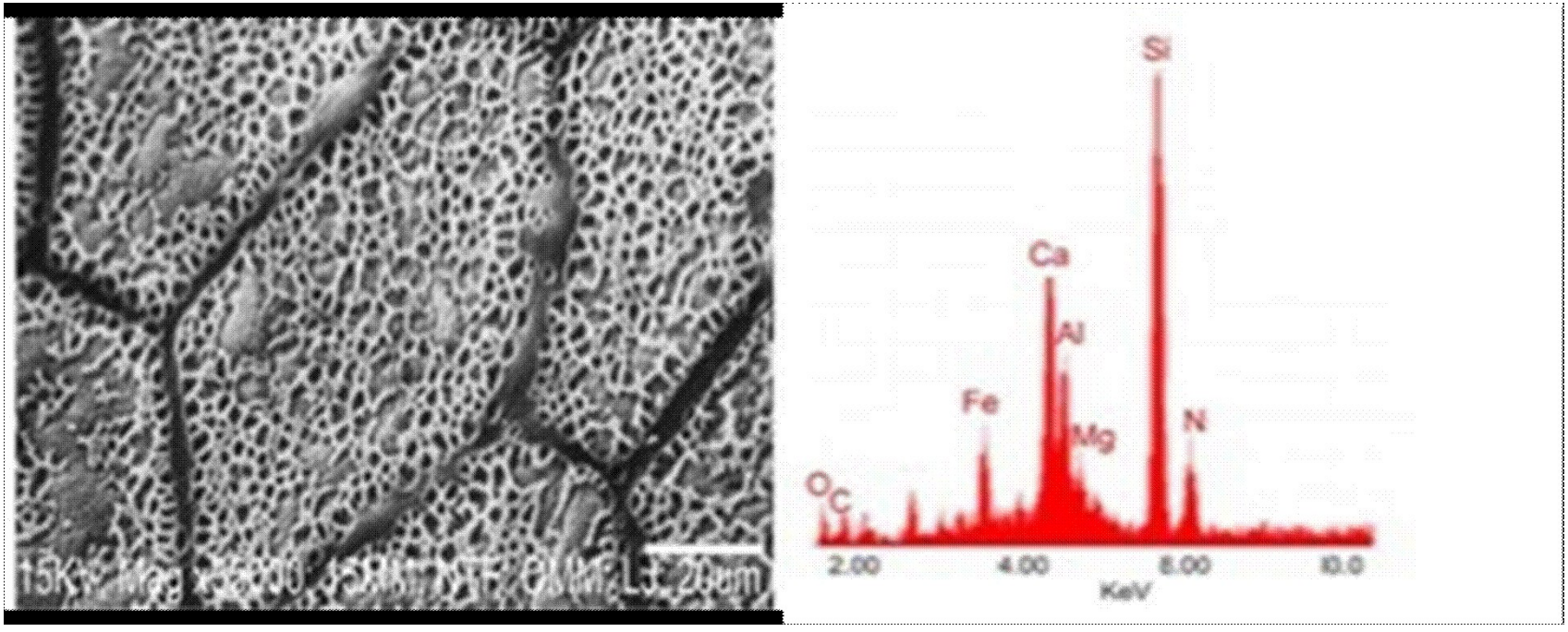

Figure 10: SEM AA6061

Scanning Electron Microscope | 3 wt % Chitosan

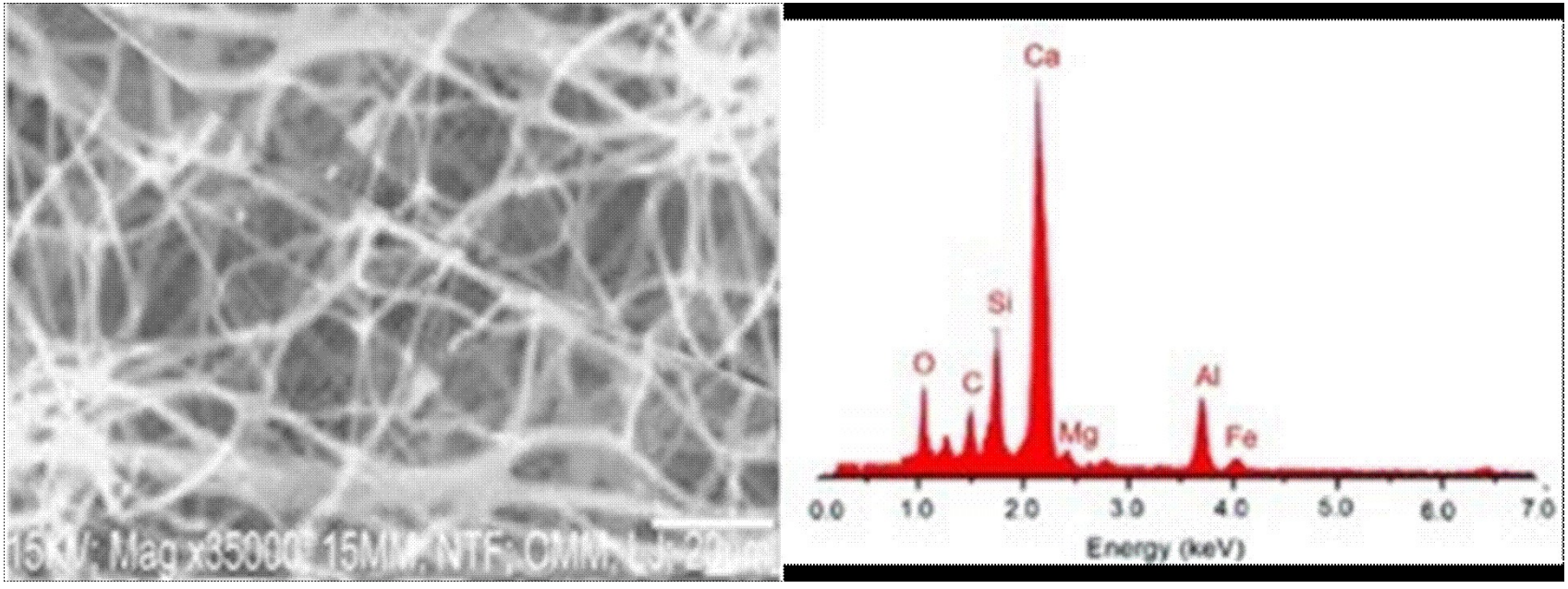

Figure 11: SEM AA6061 + 3 wt % Chitosan

Scanning Electron Microscope | 6 wt % Chitosan

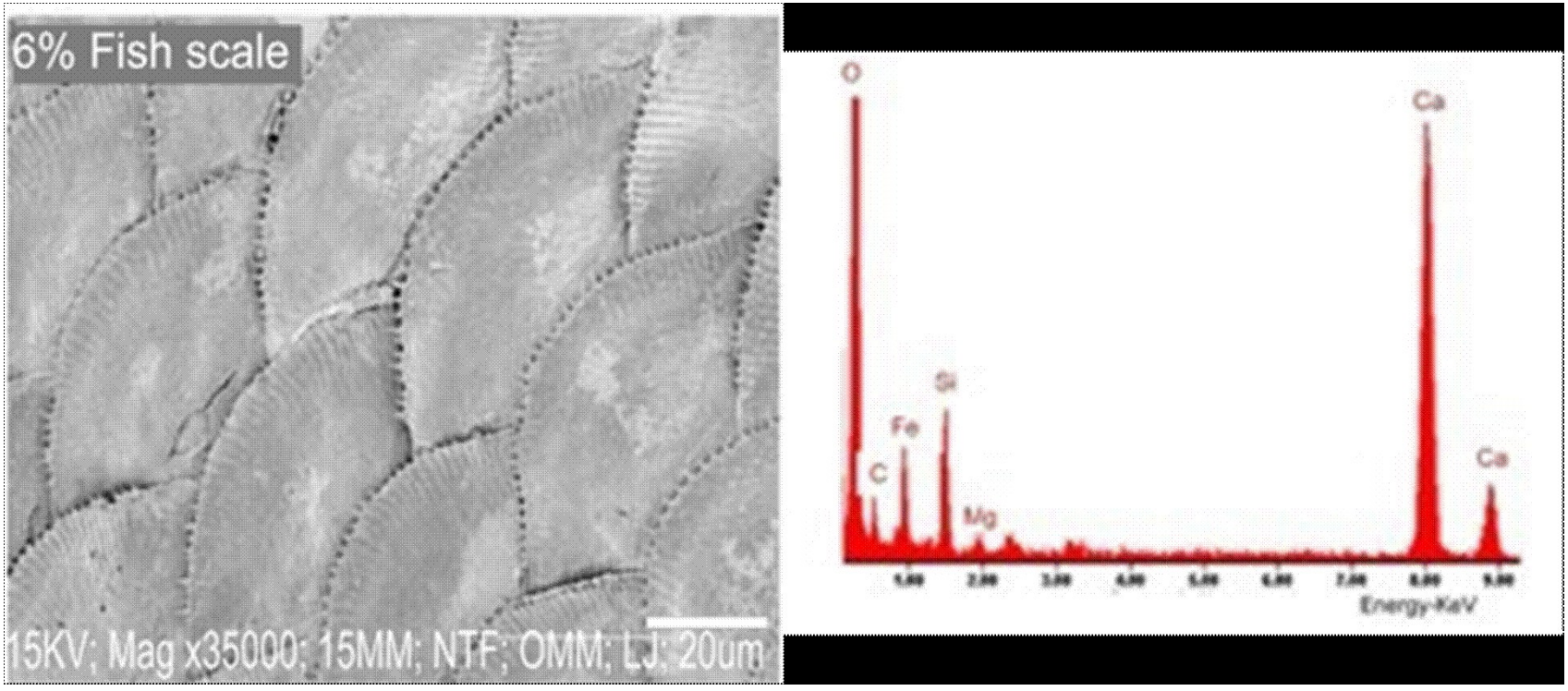

Figure 12: SEM AA6061 + 6 wt % Chitosan

Scanning Electron Microscope | 9 wt % Chitosan

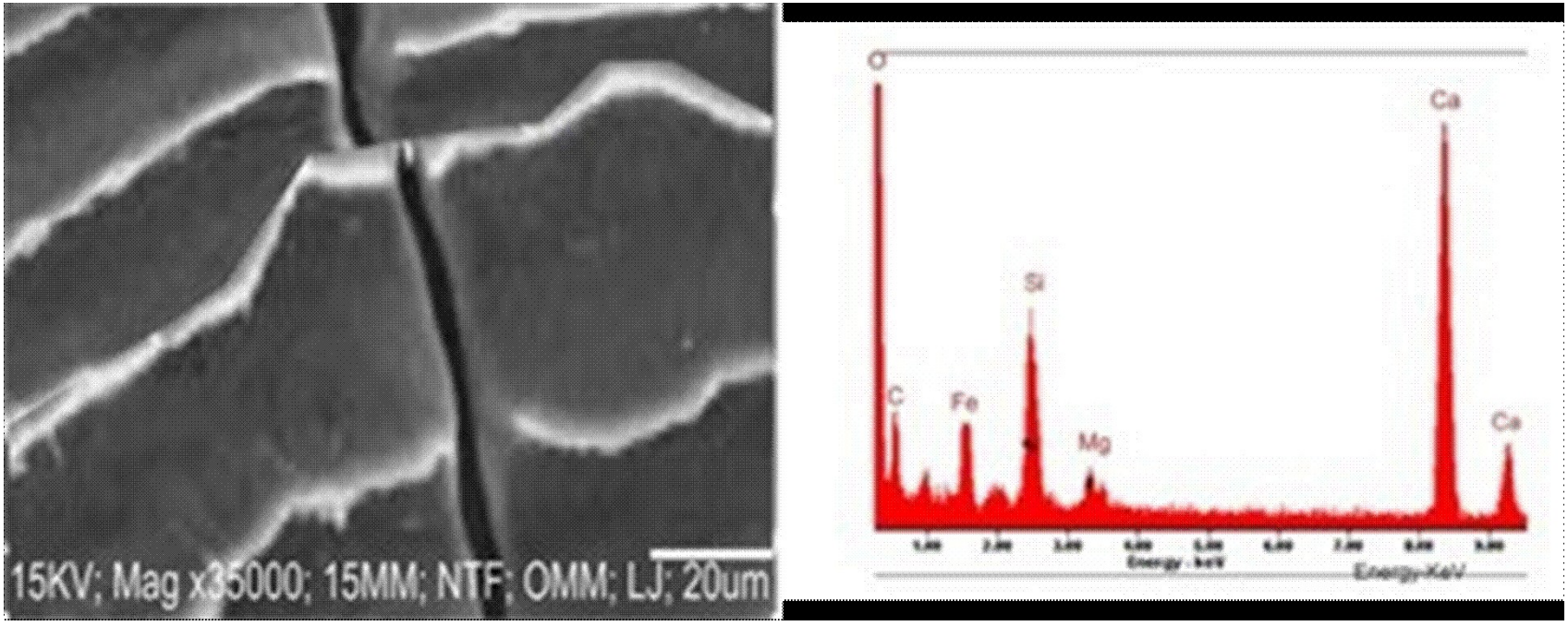

Figure 13: SEM AA6061 + 9 wt % Chitosan

Scanning Electron Microscope | 12 wt % Chitosan

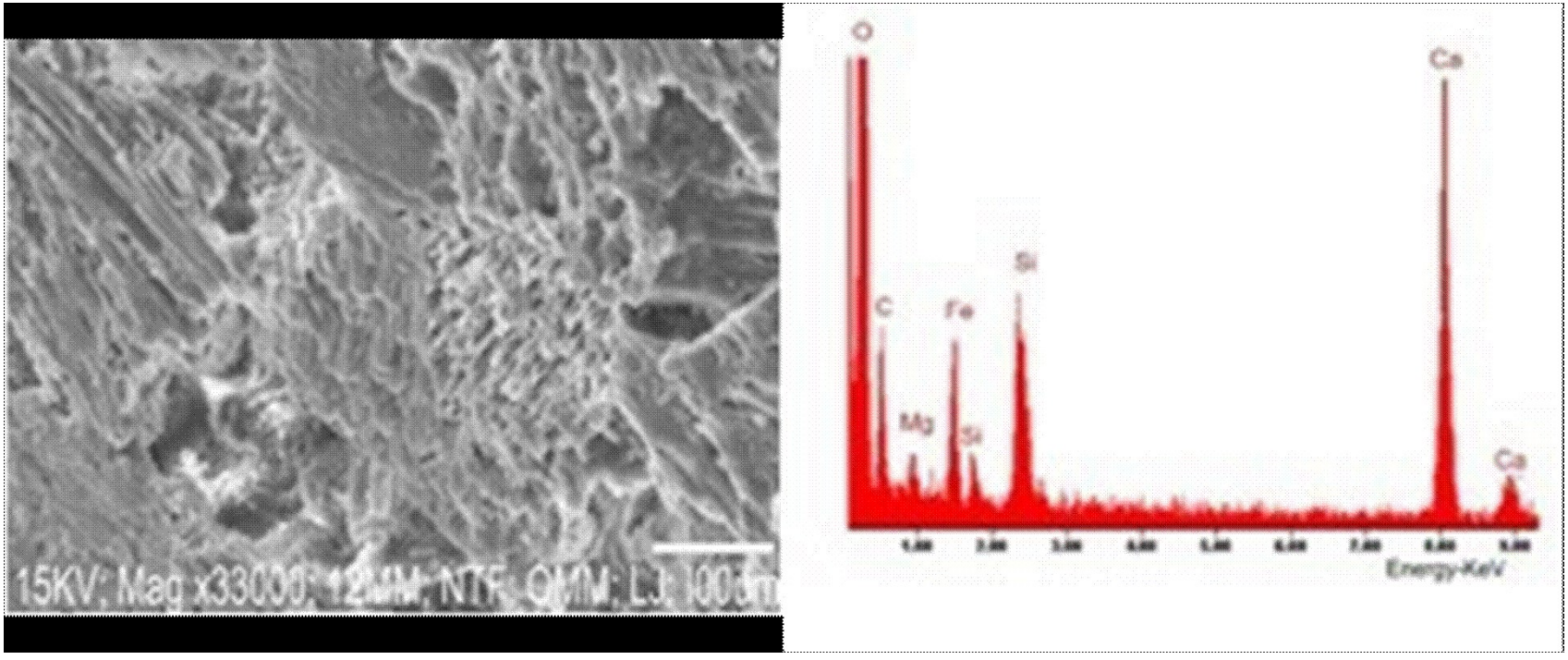

Figure 14: SEM AA6061 + 12 wt % Chitosan

Conductivity

Specimen	Voltage (V)	Current (A)	Conductivity (S/m)
AA6061	0.5	1.19	37.81
AA6061 + 3wt. % Chitosan	0.5	1.14	36.21
AA6061 + 6wt. % Chitosan	0.5	1.15	36.61
AA6061 + 9wt. % Chitosan	0.5	1.12	35.49
AA6061 + 12wt. % Chitosan	0.5	1.20	38.20

Conclusions

- Hardness of the developed composites improved with higher concentration of chitosan particulate; 9 wt.% chitosan reinforced sample developed a substantial 4.88 % improvement.
- The electrical conductivity of aluminium matrix composite reinforced with chitosan was reduced compared to unreinforced AA6061 because of the introduction of insulation from chitosan reinforcement
- The synthesized composites showed enhanced tensile strength performance with a 25.8 % increase observed the 12 wt.
- Stir casted AA6061/chitosan provided reduced conductive heat transfer coefficient compared to as-cast AA 6061

Appreciation

Thank You for listening

Questions ?

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