



**RESEARCH ARTICLE**

**FABRICATION AND PHYSICOCHEMICAL PROPERTIES OF ALGINATE-COFFEE BIOFILM FOR WOUND HEALING APPLICATION**

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**Abstract.** Alginate is extracted from seaweed with a gel-forming abilities was used to combined with coffee's bioactive compounds to enhance its potential that could be useful for biomedical applications. To achieve the desired mechanical strength, stability of biofilms and overcome the issue of sustainability, the alginate/coffee biofilms were fabricated, by sodium alginate diluting in distilled water at percentage 1w/v and ground coffee Robusta was added to that solution at weights of 0.1g, followed with the solution casting process and cross-linked with different time with calcium chloride solution at a concentration of 0.1 M. Scanning electron microscopy (SEM) analysis shows alginate/coffee biofilm of coffee weight 0.1 g, resting for 1 hour before crosslinking have the formation of loose-packed crystal structure. Energy dispersive X-ray (EDX) spectroscopy result showed compositional outcome are O, Na, Cl and Ca at the Alginate/coffee biofilm. Fourier transform infrared spectroscopy (FTIR) analysis of alginate/coffee biofilm of coffee weight 0.1g, resting for 1 hour before crosslinking verifies the appearance of absorption band at a wavenumber of  $3264.95\text{ cm}^{-1}$ ,  $1597.90\text{ cm}^{-1}$  and  $1023.07\text{ cm}^{-1}$  indicate the presence of functional group of alginate and coffee. Atomic force microscopy (AFM) showed surface roughness of alginate/coffee biofilm of coffee weight 0.1g with resting time 1 hour before crosslinked was 124.155 nm, respectively. It was found the rougher the surface enhances the adhesiveness properties of the film to the wound site. Hydrophilicity properties were determined by contact angle testing to show it is suitable for absorbing any liquid from the open wound. Alginate/coffee biofilm samples showed hydrophilicity properties as the contact angle was less than 90 degrees. This study offers insight the suitability of the chosen material for biomedical application in the wound healing process.

**Keywords:** Alginate, coffee, biofilms, physicochemical characteristics, wound healing.

**Article Info**

Received 7 March 2025

Accepted 11 June 2025

Published 4 December 2025

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ISSN: 1823-7010, eISSN: 2600-7444

## 1. INTRODUCTION

Biomaterials are a quickly advancing area in materials science, with a big impact on modern medicine and healthcare. Over recent decades, the global market has witnessed the use of various materials in the context of wound care applications [1]. Materials commonly used and extensively researched for their medical applications in wound healing can originate from both synthetic and natural sources. The demand for advanced wound care materials has led to extensive research into natural biomaterials such as alginate have gained prominence for their excellent biocompatibility and ability to integrate smoothly with the body's biological processes. The utilization of these materials in wound healing endeavors is driven by their unique properties and advantages [2,3]. In addition, Wang et al. [1] stated the challenges in application wound healing are also include like ensure that biomaterials are fully compatible with human tissues. The body's immune system may perceive the biomaterial as a foreign substance, which causes inflammation and infection. Also, large-scale production is difficult, as maintaining consistency in quality and functionality is challenging, especially for complex biomaterials requiring specialized manufacturing methods.

The common wound dressings, such as gauze, hydrocolloids, and synthetic polymers, primarily provide physical protection and moisture retention but often lack bioactive properties that actively promote tissue regeneration, thereby shortening healing time, reducing the number of dressing changes, and alleviating pain in patients compared with alginate dressing [4]. However, pure alginate films often suffer from poor mechanical strength and limited bioactive properties, necessitating modifications to enhance their therapeutic potential [5]. In addition, the Alginate-coffee biofilm has gained popularity as a potential biomaterial for wound healing. Despite its abundance in nature and potential biocompatibility, the use of alginate-coffee biofilm for wound healing is still relatively new and requires further investigation to fully understand its properties and potential applications [2,5]. Sodium alginate is a natural polymer with interesting properties for application in biomaterials. The chemical structure of alginate consists of  $\beta$ -D-mannuronic acid (M) and  $\beta$ -L-guluronic acid (G). Sodium alginate has high compatibility with most anionic substances, film-forming ability and is fully biodegradable [5,6]. Biomaterials developed from alginate demonstrate high regenerative potential, including wound healing, and can be combined with other polymers to increase the ability to adjust their properties. The unique properties polysaccharides as ideal materials for self-healing hydrogels like alginate. Alginate also offers several natural benefits for biomedical use, including being hydrophilic, highly biocompatible, and non-immunogenic [2,5].

Coffee, a popular beverage, has potential for biomedical applications due to its rich polyphenolic compounds, caffeine, and antioxidants. Its intrinsic properties can be used to create innovative biomaterials for wound healing, particularly when combined with alginate. In studied Socha et al. [7] stated the absorption spectra of the alginate films with the coffee show some bands of the coffee components like caffeine, lipids, chlorogenic acids and carbohydrates. The bioactive compounds in coffee, particularly chlorogenic acids, have been extensively studied for their antioxidant and anti-inflammatory properties. While, Lipids have an important role in wound healing by regulating inflammation, blood vessel formation and tissue repair. They are present in the epidermis, where they build the cell's lipid bilayer and produce fatty acids for fuel. This review investigates the many roles of lipid signals in wound healing [8]. Furthermore, the coffee has benzopyrone as a defense mechanism stimulating the macrophages to phagocytize the microbes, foreign bodies, and debris and clean the wound [9].

The primary objectives of this research are to fabricate the process and characterize the physiochemical properties of alginate and coffee biofilm for wound healing applications by using the solution casting method. By explained the interactions between alginate and coffee components, as well as evaluating the film's mechanical strength, biodegradability, and bioactivity, this study seeks to contribute valuable insights into the development of advanced wound dressings [6,9]. Developing biofilms with the required mechanical strength and stability to withstand external forces without disintegrating is a significant challenge. The mechanical properties of alginate are controlled by the type and concentration of cross-linking agents, such as calcium chloride. Calcium chloride can generate

strong gels by bonded to the carboxylate groups in alginate. Coffee's antioxidants, anti-inflammatory, and antimicrobial properties make it ideal for wound dressings [6,8,10]. The goal is to design biofilms that not only provide effective wound coverage but also actively facilitate the healing process, offering patients a faster and more efficient path to recovery.

This approach combines the biocompatibility and gel-forming abilities of alginate with the antimicrobial and antioxidant properties of coffee. The resulting biofilm is expected to maintain a moist wound environment, allowing for faster and more effective healing [9,11,12]. Analytical techniques such as scanning electron microscopy (SEM), atomic force microscopy (AFM), fourier transform infrared spectroscopy (FTIR) and contact angle measurements will be used to evaluate the biofilm's properties and effectiveness. The successful development of these biofilms could lead to significant advancements in wound care, providing a natural, effective, and sustainable solution for wound management.

## 2. MATERIALS AND METHODS

The materials used in the experiment to fabricate the alginate/coffee biofilm are sodium alginate powder, calcium chloride dihydrate powder were obtained from Sigma Aldrich and ground coffee Robusta from MyViet.

### 2.1 Preparation and Fabrication of Alginate- Coffee Biofilm

In the fabrication of the experiment, calcium chloride and distilled water were used to make solutions. The calcium chloride ( $\text{CaCl}_2$ ) concentration at 0.1 M was fined to use because high concentration of calcium chloride can reduce the ability of the biofilm to contain water [13]. The overall fabrication steps are illustrated in Figure 1. The 100 ml of distilled water and 1.11 gram of calcium chloride is poured into a beaker of the appropriate size, set on a magnetic stirrer, and stirred with a stirring bar until it fully dissolved.

Next, sodium alginate and distilled water were used to make other solutions at a 1 w/v%, 100 mL of distilled water poured into a beaker of the appropriate size, set on a magnetic stirrer, and stirred with a stirring bar. The magnetic stirrer temperature was kept at room temperature (no heat applied) and set at a speed that would create a vortex in the solution. 1 gram of sodium alginate is added to the mixture once the vortex has been created, and it is then given 1 hour to stir the mixture until it is fully dissolved. Before adding ground coffee Robusta into sodium alginate solution, 0.1 gram of ground coffee Robusta was measured by using analytical electronic balance and then added into the sodium alginate solution. The ground coffee Robusta was used in the range between 0.20 until 0.35mm. The sodium alginate and 0.1gram coffee was stirred for 30 minutes using a magnetic stirrer. Then the mixture was subsequently removed from the beaker to the petri dish. 25 mL of the mixture was added to each petri dish to produce three samples. Then, each sample was rested at different times before crosslinked with calcium chloride.

Lastly, every sample was rested at different times before crosslinked were sprayed with 0.1 M of  $\text{CaCl}_2$  using spray method, the calcium chloride solution was spraying into the petri dish until the mixture of alginate/coffee fully submerged. Figure 2 shows the schematic diagram for crosslinking sodium alginate and coffee film with calcium chloride by spray method. After the mixture of alginate/coffee hardened into liquid-solid phase of "agar-agar", poured out the excessive calcium chloride solution from a petri dish and dry the sample for 5-7 days at room temperature. To characterize it, the film was dried and then cut into squares measuring approximately 1.5 cm x 1.5 cm. Figure 3 (a) and (b) illustrates the ground coffee that was measured before mixing and the final dried alginate/coffee film after 5–7 days of drying, which form part of the alginate/coffee biofilm fabrication process.

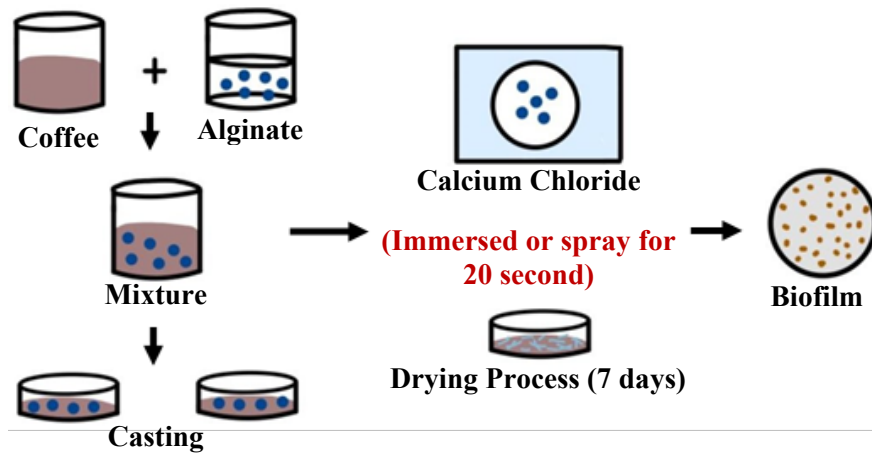


Figure 1: Schematic diagram of fabrication process

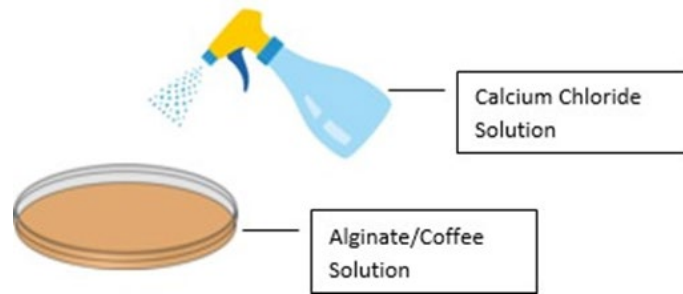


Figure 2: The schematic diagram for crosslinking sodium alginate and coffee film with  $\text{CaCl}_2$  by spraying method

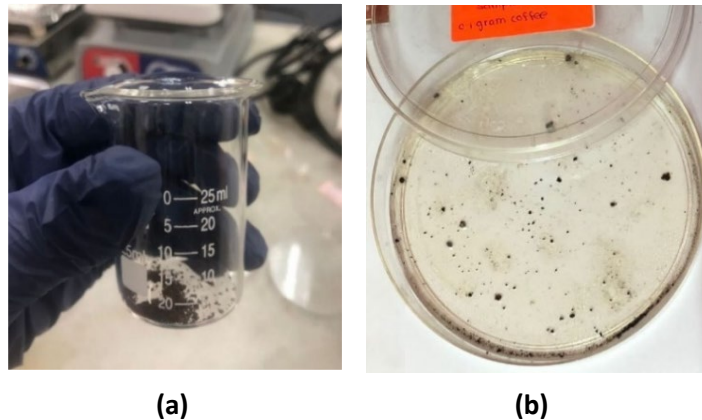


Figure 3: Process fabrication alginate/coffee biofilm (a) ground coffee robusta after measured and (b) sample after drying process

## 2.2 Characterization of Alginate- Coffee Biofilm

Alginate/Coffee biofilm was tested using various characterization and analysis method and procedure. SEM and EDX were used to examine the surface appearance and microstructural properties of alginate/coffee biofilms. This aim is to study the biofilm's physical features, such as surface texture and coffee particles spread inside the alginate matrix. Before the analysis, samples were coated with

gold using a sputter coater JOEL JFC-1600 from Japan to obtain good-quality SEM images. The surface morphology of the film sample was observed on SEM operated under a low vacuum at an accelerating voltage of 15 kV. The SEM equipment used was Hitachi SU1510, Hitachi High Technologies America Inc., USA and equipped with an energy dispersive X-ray (EDX). EDX analysis provides valuable information about the chemical composition, distribution, and sometimes the concentration of elements within the sample. FTIR was used to identify specific functional groups within biomaterials, allowing to assess the interaction between alginate and coffee components at the molecular level. It helps in finding interactions between alginate and coffee components and analyzing biofilm composition. Chemical analyses were carried out using a Fourier transform infrared (FTIR) spectrophotometer (Model 100 series, Perkin Elmer) in the range of 600 – 4000  $\text{cm}^{-1}$ . During the scanning process, apply controlled pressure to enhance the frequency response. This equipment will facilitate the identification of chemical bond vibrations and generate distinct frequency patterns in the resulting graph.

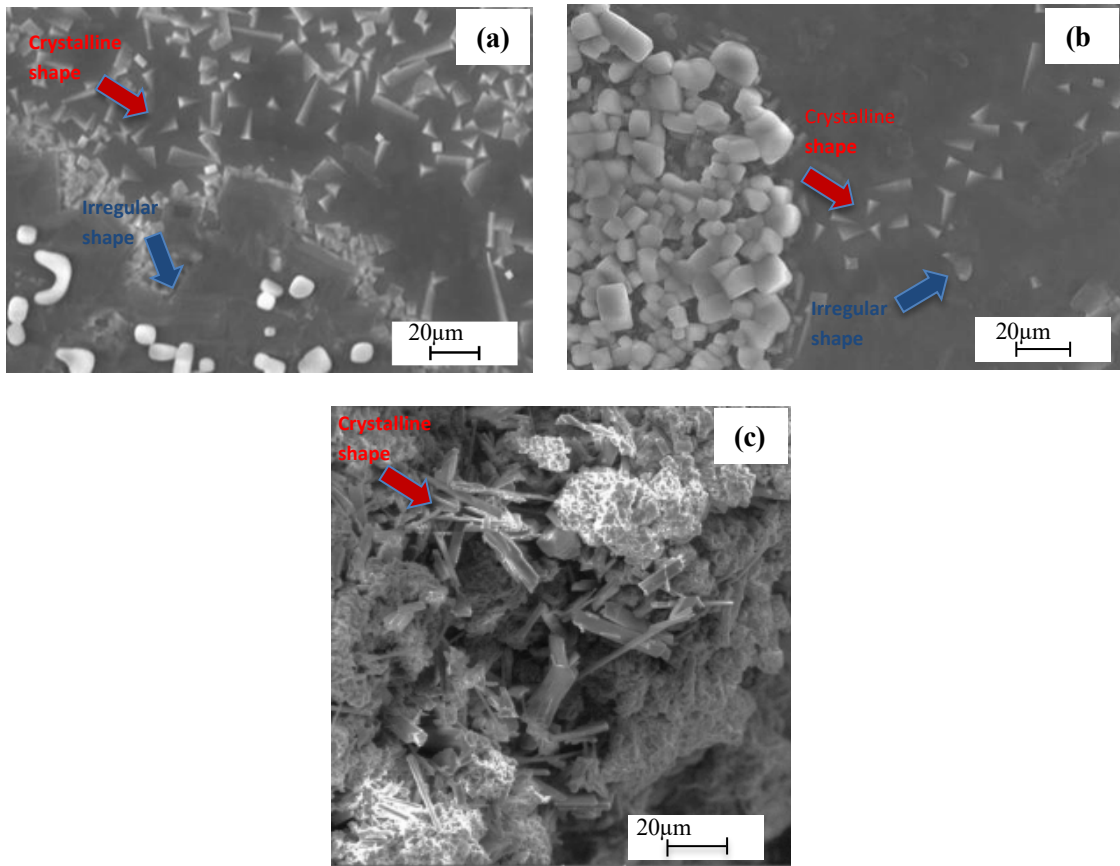
Atomic force microscope (AFM) was to assess biofilm surface topography, mechanical properties, and structural aspects at the nanoscale. XE-100 from Park System Corp, South Korea gives high-resolution images and quantitative data on the biofilm's texture, roughness, and elasticity. This information is crucial for understanding biofilm formation, adhesion, and stability, which can inform applications in wound dressing. AFM helps in assessing the effects of different treatments or environmental conditions on the biofilm's integrity and functionality. Lastly, contact angle using goniometer is a critical approach used to evaluate the surface characteristics of biomaterials, providing information on their wettability and interactions with liquids by using. A low contact angle ( $< 90^\circ$ ) indicates high wettability, allowing liquid to spread easily, while a high angle ( $> 90^\circ$ ) low wettability. The result will determine whether the biomaterial is hydrophobic or hydrophilic [14,15]. The process this analysis is drops injected in various areas of film. The standard deviation was calculated to show the accuracy of the data.

### 3. RESULTS AND DISCUSSION

#### 3.1 SEM-EDX Analysis

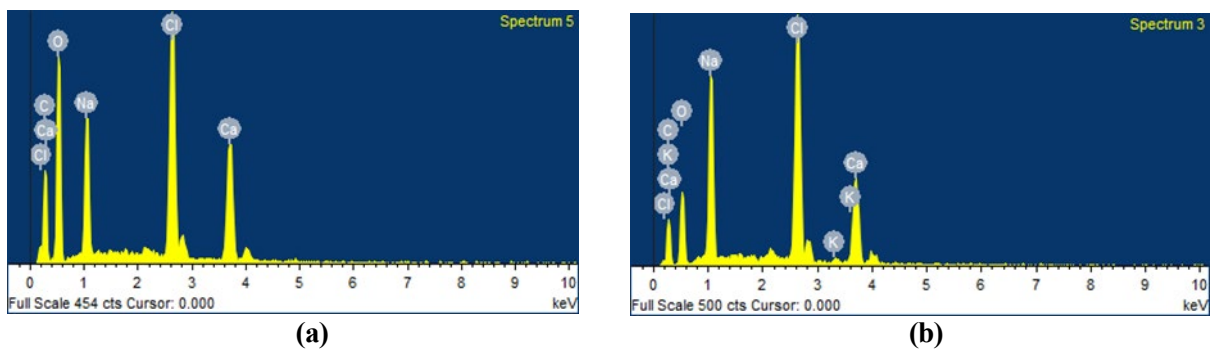
Figure 4(a) and (b) showed the SEM images at 2500x magnification of alginate/coffee biofilm with 0.1 weight coffee and alginate/coffee biofilm with 0.1 weight coffee with 1 hour resting. While Figure 4(c) illustrates the morphology of alginate biofilm by Sivalingam and Gopal [16]. In the whole figure, red arrows indicate the presence of crystalline formations, which are characteristic of calcium chloride by crosslinked. The effects of  $\text{CaCl}_2$  in biofilm were important role in determining the morphology of the biofilm alginate/coffee.  $\text{CaCl}_2$  It produced crystal a columnar shape, with morphologies that tend to be very fine prismatic granulates [17]. The surface of alginate/coffee biofilm also showed complex structure, with the particles appearing as separate entities with blue arrows indicate irregular shape and red arrow crystalline formations. This reveals the phases of crosslinking on a finer scale, as well as the distribution of calcium ions in the alginate/coffee matrix. The studies by Reyes-Pérez et al. [18] prove the surface morphology of the ground coffee, showing highly variable, lumpy, and irregular shapes.

Upon comparing our findings with prior research [19], it becomes evident that the morphological characteristics of the alginate biofilm exhibit similarities to alginate/coffee biofilm. Calcium-crosslinked hydrogels Figure 4(c) show a quite smooth morphology, however, the hydrogels crosslinked with  $\text{CaCl}_2$  was added with coffee. Figure 4(a) and (b) show a rough morphology. This observation can be related to the cooperative interaction between metallic cations and mannuronic (M) and guluronic (G) sequences within the structure of alginate.  $\text{Ca}^{2+}$  binds to the G blocks and mannuronic-guluronic blocks (MG) containing alternating M and G residues [19]. Noting that the sample with resting time also showed a considerable change, showed particles more densely packed and have a clearer crystalline structure, showing that extended crosslinking results in a more rigid and linked network.



**Figure 4:** Micrographs of samples alginate/coffee biofilm of 0.1 gram coffee crosslinked with 0.1 M of  $\text{CaCl}_2$  (a) directly crosslinked, (b) 1 hours resting time and (c) alginate biofilm by Sivalingam and Gopal [16]. The red and blue arrows indicate the the crystalline and irregular shape, respectively

Figure 5 and Table 1 show the existence of element composition in the alginate/coffee biofilms with 0.1 weight. The EDX spectrum obtained from analysis of sample alginate/coffee biofilm that had been cross-linked with calcium chloride, as depicted in Figure 5(a) revealed the presence of carbon (C), oxygen (O), sodium (Na), chlorine (Cl), and calcium (Ca). Carbon and oxygen dominate the composition, reflecting the organic nature of the alginate and coffee components. The presence of calcium, even in lower quantities, signifies its role in crosslinking. After 1 hour of resting time before crosslinked, the elemental composition shows notable changes as shown in Figure 5(b). Oxygen content decreases, while sodium and chlorine contents increase significantly. coffee crosslinked with concentration of 0.1 M  $\text{CaCl}_2$ .



**Figure 5:** EDS elemental graph analysis of 2 parameters samples biofilm: (a) alginate/coffee biofilm crosslinked with 0.1M of  $\text{CaCl}_2$  and (b) alginate/coffee biofilm crosslinked with 0.1M of  $\text{CaCl}_2$  with 1 hour resting time.

**Table 1:** EDS elemental analysis of alginate biofilm crosslinked with 0.1 M of CaCl<sub>2</sub> and alginate/coffee biofilm crosslinked with 0.1 M of CaCl<sub>2</sub> with 1 hour resting time

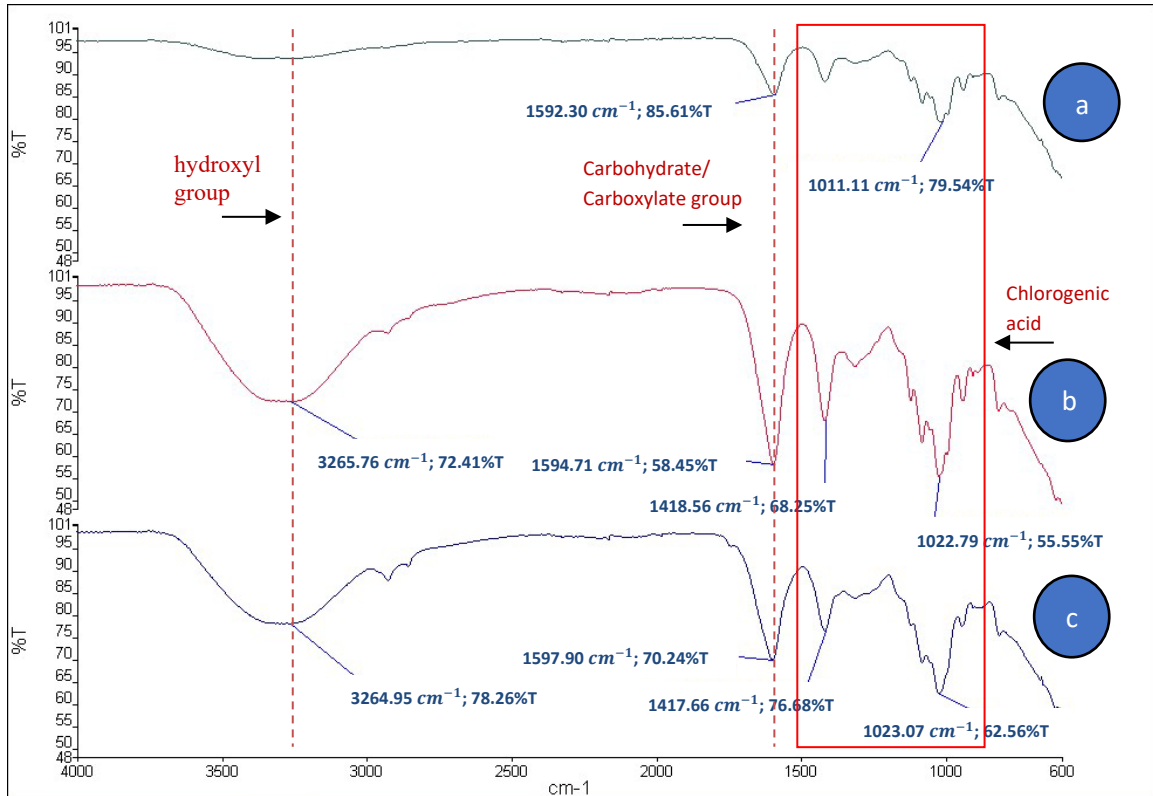
Sample Element	A		B	
	Weight (%)	Atomic (%)	Weight (%)	Atomic (%)
O	38.59	41.45	11.28	19.05
Na	6.94	5.19	32.05	37.68
Cl	14.76	7.16	46.56	35.49
Ca	10.60	4.54	5.99	4.04
C	29.11	41.66	-	-
Al	-	-	1.36	1.36
Si	-	-	1.75	1.68
K	-	-	1.01	0.70

### 3.2 Fourier transform infrared spectroscopy (FTIR)

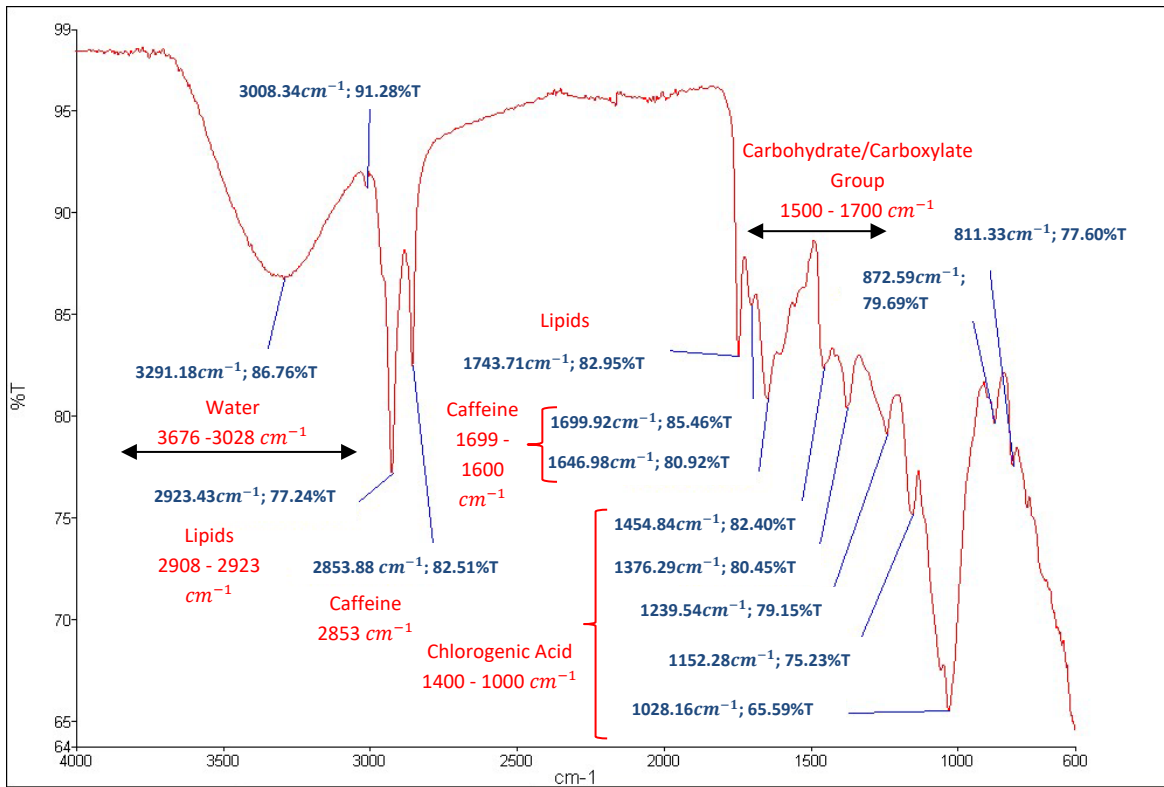
Figure 6 illustrates the comparison of FTIR spectra for alginate/coffee biofilm with 0.1 gram of coffee in different time rest before crosslinking with calcium chloride which affects the transmittance percentage and Figure 7 shows the Spectrum for Ground Coffee Robusta to make a comparison of region functional group of coffee. In Figure 6 showed big different percentage of transmittance at functional group region of alginate where peak at  $3265.76\text{ cm}^{-1}$  with 72.41 % (b) and peak at  $3264.95\text{ cm}^{-1}$  with 78.26% (c) were broad and contributed by OH stretching vibrating which it typical of alcohols, phenols, or carboxylic acids, suggesting the presence of hydroxyl groups in the biofilm [20]. Previous study by Borriello et al. (2025) reported that in alginate biofilms, broad absorption bands between  $3100\text{--}3500\text{ cm}^{-1}$  in alginate biofilm are due to O–H and N–H stretching, intensified by interactions of hydrophilic compounds with water. A distinct absorption at  $1637\text{ cm}^{-1}$  corresponds to carboxylate and protonated carboxylate groups in the alginate [21].

By comparing with Figure 7, the spectrum on Figure 6 showed the different percentage of transmittance at functional group region of coffee got 85.61%, 58.45% and 70.24% of carboxylate groups at wavenumber  $1592.30\text{ cm}^{-1}$  (a),  $1594.71\text{ cm}^{-1}$  (b) and  $1597.90\text{ cm}^{-1}$  (c). This peak corresponds to the C=O stretching vibrations, typically in alginates and with slight shifts possibly due to interactions with coffee components or changes in biofilm structure over time. The value is continuing to the wavenumber of  $1418.56\text{ cm}^{-1}$  (b) and  $1417.66\text{ cm}^{-1}$  (c) which is CH bending vibrations of the carboxylate ions in alginate where the values of  $CH_2$  is increase to 68.25 % and 76.68%. The wavenumber range is decrease to  $1022.79\text{ cm}^{-1}$  at 55.55 % (b) and  $1023.07\text{ cm}^{-1}$  at 62.56 % value (c) in groups C-O-C vibration in esters. While peak at  $1011.11\text{ cm}^{-1}$  (a) is found with 79.54% in C-O-C vibrations in ester also, the presence of polysaccharide or other carbohydrate structures.

The peaks of chlorogenic acid, which occurs by esterification between quinic acid and caffeic acid, showed in the range of  $1450\text{--}1000\text{ cm}^{-1}$  [20,21]. This shows that the effect of coffee in the fabrication of alginate/coffee biofilm that contains 0.1g of coffee influences the percentage of transmittance which represents as the light passed through the sample. Table 2 shows in more detail the wavenumber and transmittance for functional groups for each peak of alginate biofilm with different resting times. In conclusion, Fourier transform infrared spectroscopy (FTIR) helps to prove the presence of chemical compounds in the biofilm as a wound healing process. It allows monitoring chemical composition alterations and changes in a subcellular level [22].



**Figure 6:** FTIR spectrum of alginate/coffee biofilm with (a) directly crosslinked, (b) resting time 30 minutes and (c) resting time 1 hour before crosslinked with 0.1 M of  $CaCl_2$



**Figure 7:** FTIR spectrum for ground coffee robusta

**Table 2:** Functional group for each peak of alginate/coffee biofilm with different resting time

Functional Group	Resting Time	Wavenumber	Transmittance
OH, stretching vibrating	Directly	-	-
	30 minutes	3265.76 $\text{cm}^{-1}$	72.41 %
	1 hour	3264.95 $\text{cm}^{-1}$	78.26%
C=O Stretching Vibrations	Directly	1592.30 $\text{cm}^{-1}$	85.61%
	30 minutes	1594.71 $\text{cm}^{-1}$	58.45%
	1 hour	1597.90 $\text{cm}^{-1}$	70.24%
CH bending vibrations of the carboxylate ions	Directly	-	-
	30 minutes	1418.56 $\text{cm}^{-1}$	68.25 %
	1 hour	1417.66 $\text{cm}^{-1}$	76.68%
C-O-C vibrations in ester	Directly	1011.11 $\text{cm}^{-1}$	79.54%
	30 minutes	1022.79 $\text{cm}^{-1}$	55.55 %
	1 hour	1023.07 $\text{cm}^{-1}$	62.56 %

### 3.3 Atomic Force Microscope (AFM)

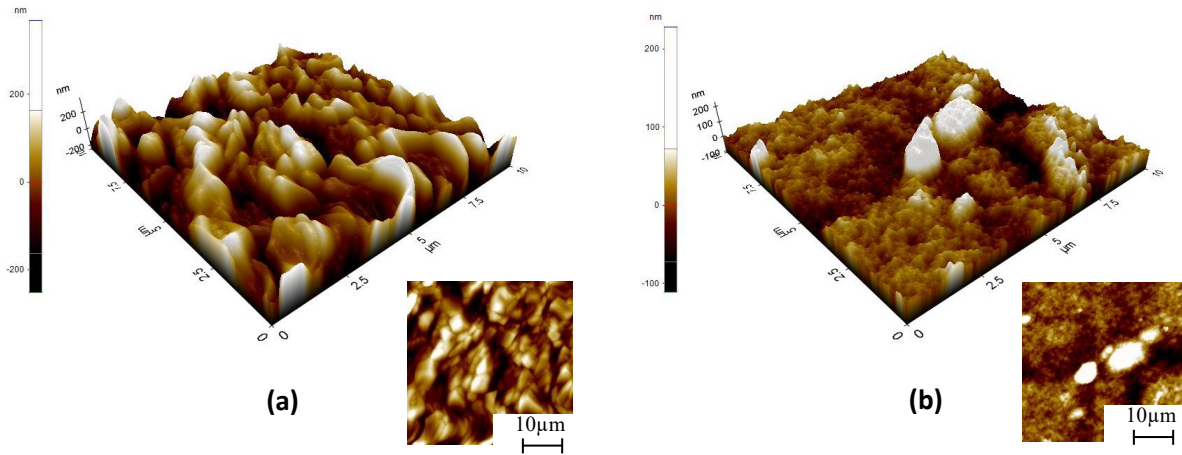
Atomic Force Microscopy (AFM) analysis was conducted to investigate the surface topography and roughness parameters of alginate/coffee biofilm crosslinked with 0.1 M  $\text{CaCl}_2$ . Two conditions were studied which are (a) directly crosslinked and (b) crosslinked after a resting time of 1 hour. The surface roughness was quantified using three parameters which are peak-to-valley roughness (Rpv), root mean square roughness (Rq), and average roughness (Ra). The results are summarized in Table 3 and illustrated in Figure 8.

From the AFM images, a clear increase in surface roughness was observed in the sample with a 1 hour resting time before crosslinking. The (Rpv) increased from 711.095 nm to 794.641 nm, while (Rq) increased also from 81.179 nm to 155.449 nm, and (Ra) increased significantly from 57.951 nm to 124.155 nm. These findings indicate that allowing the alginate/coffee mixture to rest for 1 hour prior to crosslinking enhances the surface roughness of the resulting biofilm. Greater surface roughness is favourable in biomedical materials, especially for wound healing, because it supports cell attachment, spreading, and proliferation.

Additionally, the incorporation of coffee, rich in bioactive polyphenols, may influence the hydrophilicity and topography of the biofilm surface. According to Majhy et al. [23] rougher surfaces promote enhanced cellular responses and can improve tissue regeneration outcomes. Also, natural additives like coffee can significantly modulate roughness of biofilm.

**Table 3:** Roughness parameter for alginate/coffee biofilm crosslinked with 0.1 M  $\text{CaCl}_2$ 

Resting Time	Surface Roughness Parameter		
	Roughness Peak to Valley, Rpv (nm)	Roughness Root Mean Square, Rq(nm)	Roughness Average, Ra(nm)
Directly Crosslinked	711.095	81.179	57.951
1 Hours	794.641	155.449	124.155



**Figure 8:** 2D and 3D AFM image of alginate/coffee biofilm crosslinked (a) concentration 0.1 M  $\text{CaCl}_2$  without resting time and (b) 1 hour resting time

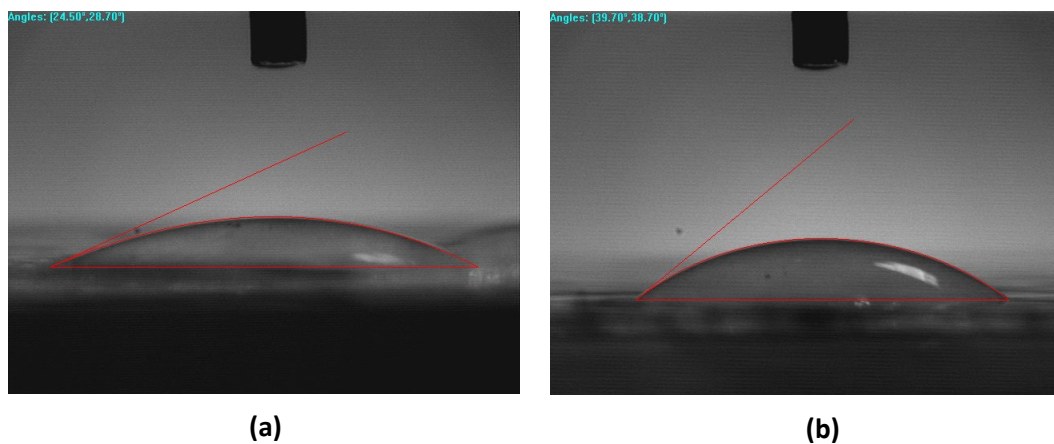
### 3.4 Contact Angle Measurement via Goniometer

The surface wettability of alginate and coffee films was evaluated using contact angle measurements. Table 4 shows the contact angle value for alginate /coffee biofilm with 0.1 g of coffee crosslinked with concentration of 0.1 M  $\text{CaCl}_2$ .

**Table 4:** Contact angle value for alginate/coffee biofilm crosslinked with 0.1 M  $\text{CaCl}_2$

Resting Time	Contact Angle (°)			
	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	Average
Directly Crosslinked	28.70	25.40	22.10	25.40
1 Hours	38.70	35.30	33.70	35.90

Figure 9 shows the image of the contact angle of alginate/coffee biofilm of 0.1 grams of coffee crosslinked with 0.1 M of  $\text{CaCl}_2$  to prove its hydrophilicity nature.



**Figure 9:** Contact angle of alginate/coffee biofilm crosslinked with 0.1 M of  $\text{CaCl}_2$  (a) without resting time and (b) 1 hour resting time

The contact angles for all samples are below 90 degrees, indicates the surface is hydrophilic and has a good surface ability. The highest average contact angle, which is 35.90°, makes it the least hydrophilic among the samples (Figure 9(a)). In contrast, the lowest average contact angle, which is 25.40°, shows the highest hydrophilicity. The value for all samples indicates that the surface is hydrophilic and absorbs water for good moisture retention and adhesion to wound sites because coffee is a hydrophilic substance. Coffee grounds contain hydrophilic antioxidant compounds such as chlorogenic acids and caffeine, which show antioxidant activity and contribute to the hydrophilic nature of coffee. Coffee beans also contain oils, which are released when ground. These oils contribute to coffee's hydrophobic properties [24].

#### 4. CONCLUSIONS

In summary, the addition of coffee to alginate biofilms improves their physiochemical characteristics, making them suitable for wound healing applications. The combination of alginate and coffee's bioactive chemicals shows great promise for application in biomedical, with characterization approaches providing detailed insights into the biofilm's structural and functional properties such as:

- Exhibits optimal surface roughness and uniform bioactive compound distribution.
- Satisfactory mechanical properties that ensure cell adhesion and proliferation.

Also, it will be great as well if in the future to evaluate the antibacterial properties of this biofilm and increase the surface area of the coffee by having a finer or micron level size to optimize their function. Finally, it is suggested that alginate/coffee biofilm leads to an ideal material for effective wound healing treatments.

#### Acknowledgments

This research was supported by Universiti Tun Hussein Onn Malaysia (UTHM) through Multidisciplinary Research Grant, MDR (vot: Q725) and Postgraduate Research Grant, GPPS (vot: Q786).

#### Author Contributions

All authors contributed toward data analysis, drafting and critically revising the paper and agree to be accountable for all aspects of the work.

#### Disclosure of Conflict of Interest

The authors have no disclosures to declare.

#### Compliance with Ethical Standards

The work is compliant with ethical standards

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