Development of novel pectin-based biofilms as food packaging materials

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Abstract

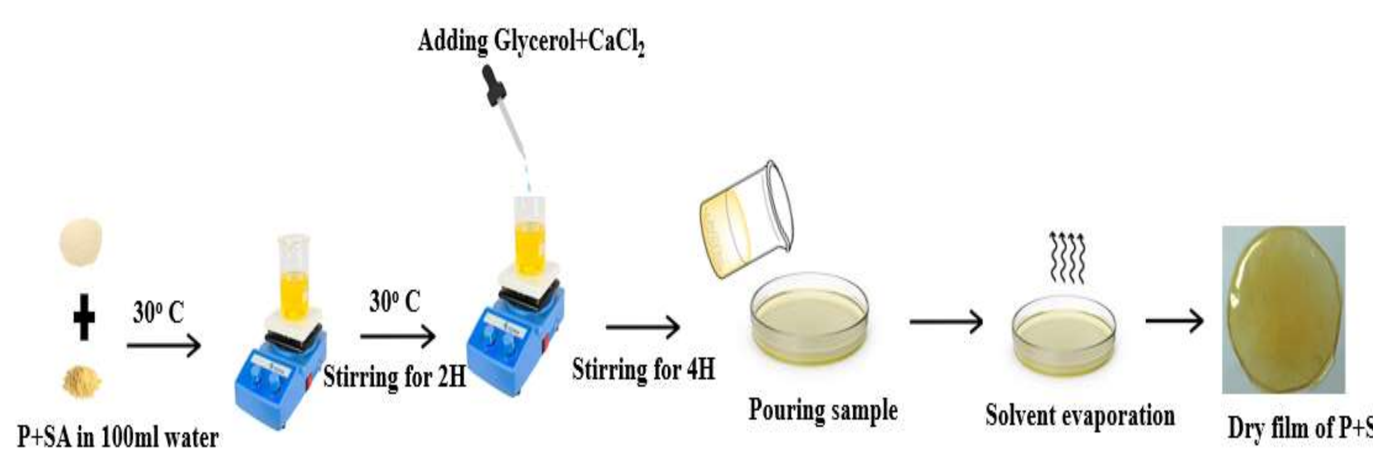
In recent years, there has been a significant drive to switch from non-renewable resources to ecologically favourable renewable materials. A similar attempt was made in the current work to substitute food packaging films made of synthetic polymers with films composed of renewable materials derived from trash. The films for pectin, alginate, P/SA, and P/SA/O were produced and analysed in order to ascertain their suitability for packaging. Films composed of sodium alginate and pectin were casted using calcium chloride as crosslinker in order to improve their functionality and glycerol as a plasticizer. Essential oil sample was incorporated into the polymer blend matrix to increase the mechanical strength and thermal stability of films. Biofilms were characterized by different spectral techniques to confirm the composition and morphology of the films. The mechanical properties of the films were measured to to assess the prepared films' appropriateness for the intended use. The biodegradation studies of prepared films revealed that, the films will decompose under ambient settings over an appreciable amount of time, suggesting that they would be a preferable choice for edible coatings and ecologically friendly food packaging.

Introduction

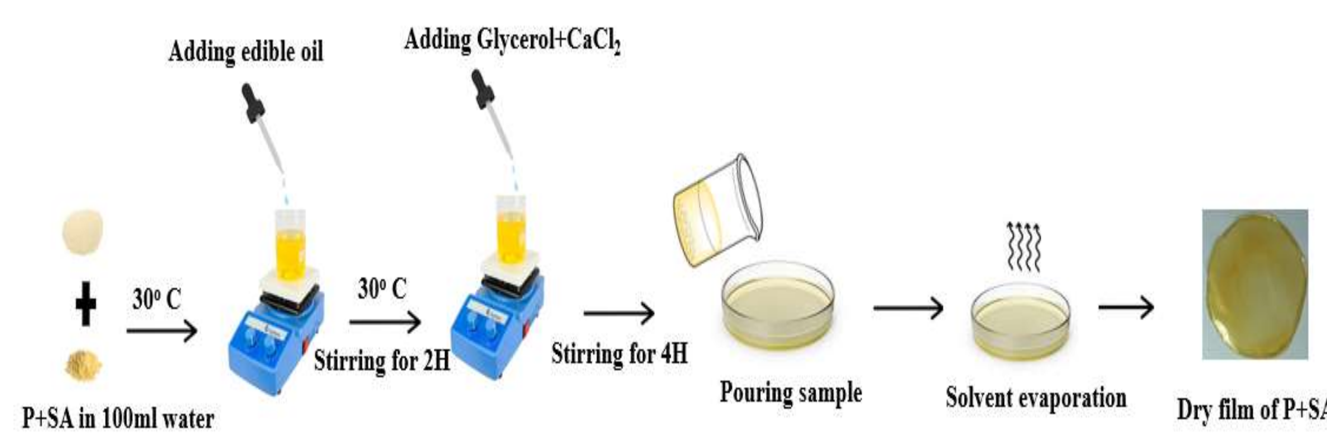
Biopolymers are the organic substances present in natural sources. The term biopolymer originates from the Greek word's bio and polymer, representing nature and living organisms. Large macromolecules made up of numerous repeating units are known as biopolymers. The biopolymers are discovered to be biocompatible and biodegradable, making them useful in a variety of applications, including edible films, emulsions, packaging materials, and medical implants like organs, wound healing, tissue scaffolds, and dressing materials in the pharmaceutical industries. Pectin is a broad word for a group of natural polymers found in all land-growing plants as structural elements. In terms of food composition, pectin is a gelling agent. Pectin is a naturally occurring, high-molecular-weight, anionic, non-toxic polysaccharide that is obtained from the cell walls of higher plants. Pectin is a desirable innovative biopolymer material that can be used in the pharmaceutical sector, health promotion, and cosmetic applications because to its great gelling capabilities, strong biocompatibility, non-toxicity, and biodegradability. Another significant biodegradable polymer is a substance termed alginate, commonly referred to as alginic acid, is present in the cell walls of brown algae. Alginate has a use in the quickly expanding field of biotechnology for immobilizing cell and enzyme systems. The different applications of alginates are influenced by their physical characteristics. They are utilized in the food, cosmetic, and pharmaceutical industries as stabilizers, emulsifiers, thickeners, and gel-forming agents.

Methodology

Preparation of P/SA films



Preparation of P/SA/O films



The graphical representation of synthesis of biofilms A) P/SA B) P/SA/O

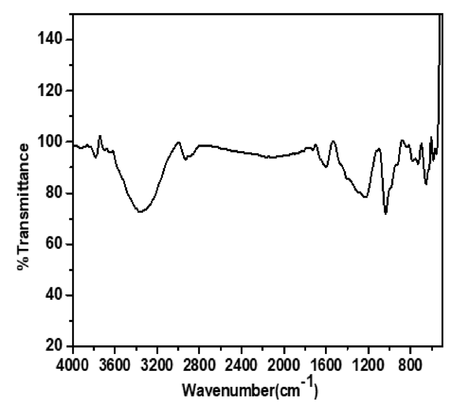
Characterisation

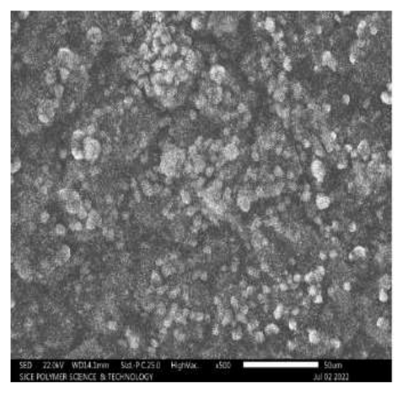
Spectral and thermal characterization of films.

Different spectral methodologies were used to characterize the P/SA and P/SA/O films. FTIR spectroscopy was performed to determine the intermolecular interactions within the film matrix. The films' FT-IR spectra were captured using a Jasco FT/IR-4100 (Japan) in attenuated total reflectance mode in the 4000-400 cm^{-1} range. The XRD analysis was used to determine the crystalline structure of the pectin films. The Proto AXRD tabletop diffractometer (Proto, Canada) produced the X-Ray diffraction pattern in the 2θ range of 5-80. Scanning electron microscope (SEM) was used to study the surfaces of casted films. Using SEM (JEOL, USA), the morphological study of films was completed. To comprehend the thermal degradation behavior, the TGA analysis (Q50, TA Instruments, USA) was carried out at a heating rate of 2°C/min between 30 and 900 °C.

Results

Characterisation of PA/SA/O





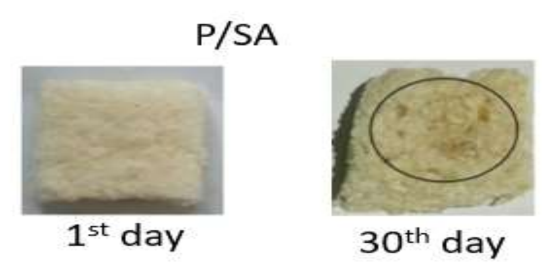
Film type	Trial No. Thickness measured in µm					Average Thickness in µm
	1	2	3	4	5	
P	17	16	14	17	18	16.4
SA	24	22	23	25	24	23.6
P/SA	18	19	18	20	17	18.4
P/SA/O	23	23	22	20	21	21.8

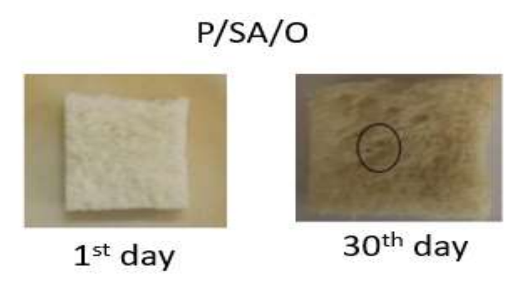
weeks	Initial weight W1	Final weigh W2	W2-W1	%Degradation
1st week	0.219	0.189	0.03	13.6
2nd week	0.221	0.157	0.064	28.9
3rd week	0.2622	0.172	0.0902	34.4
4th week	0.1980	0.0870	0.103	55.8

Film Composition	Peak load (Kg)	Tensile strength at peak load (MPa)	Elongation at Break (%)	Ultimate Modulus (MPa)
P/SA	1.96	2.48	79.76	1.58
P/SA with essential oil	0.65	0.82	91.08	9.49

Figure: A)FTIR- spectra B)SEM image C) Thickness D) Degradation E) Tensile strength of PA/SA/O

Application: Food packing





Conclusions

Ecofriendly P/SA and P/SA/O composite films with high mechanical strength was prepared by casting technique. Inclusion of essential oil led to the development of biofilms with improved elongation break exhibiting more flexibility. Although the films presented a homogeneous appearance, the SEM analysis revealed a heterogeneous and rough surface across the film matrix. These modifications, as verified by FTIR analysis, could be credited to the interaction between functional groups of biopolymers with oil. Finally, the biodegradation results demonstrated that P/SA and P/SA/O composite films can also be utilized as an eco-friendly food packaging material. Composite film exhibited perfect recyclability and favorable biodegradability in natural soil. Thus, the biofilms which are eco-friendly and biodegradable, might be a replacement of plastic material in food packaging having improved tensile properties.

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