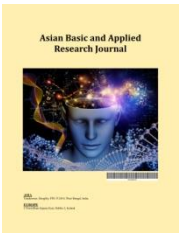

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Synthesis and Mechanical Properties of Polystyrene Blended with Sand Apricot Seed Oil (SAO) used as a Plasticizer

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Polystyrene (PS) is well recognized as the most resilient thermoplastic polymer and is utilized in a diverse array of products owing to its adaptable characteristics. The present study centres on the synthesis and mechanical characterization of polystyrene blended with sand apricot seed oil (SAO), which was used as a plasticizer. SAO was extracted with hexane and employed as a plasticizer for styrene suspension polymerization. The findings on the quality of oil were explained in terms of oil content (9.0), specific gravity (0.931 ± 0.00), acid value (12.083 ± 0.12 mg KOH), iodine value (118.987 ± 0.40), saponification values (283.271), viscosity (85.23 Ns/m^2), and refractive index (1.412). The FTIR of SAO affirmed the presence of alkene, isothiocyanate, phosphine, and alcohol, with a vibration frequency of 1607.612cm^{-1}, 2064.996 cm^{-1}, 2450.856cm^{-1} and 3896.258 cm^{-1}. The mechanical properties of the polystyrene blend with sand apricot seed oil (PS-SAO) at 100g

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obtained were ultimate tensile strength (58.6 MPa), Young modulus **(**1996.1 MPa**),** % elongation **(**13.4%), break load (500.6 N), peak load (586.7 N), and Shore D hardness (80.0). The results indicated that the mechanical characteristics of PS-SAO were comparable to those of the traditional white petroleum oil employed as a plasticizer. It is advisable to use sand apricot seed oil as a plasticizer due to its accessibility, affordability, and eco-friendliness.

Keywords: Mechanical properties; oil; plasticizers; polystyrene; sand apricot seed.

1. INTRODUCTION

Polystyrene is commonly acknowledged as the most durable thermoplastic polymer and has demonstrated resilience to biodegradation, as well as the capacity to be hard or flexible in the presence of plasticizers. It is also lightweight and possesses favourable optical, chemical, and insulating properties [1]. It is employed in various applications, such as plastics, latex paints, coatings, synthetic rubbers, and styrene alkyd coatings. It is also used in food-contact packaging polymers, electronics, building materials, and for the production of toys, cups, office supplies, and more [2,3]. However, styrene easily copolymerizes with different monomers, such as butadiene, acrylonitrile, methacrylamide, divinylbenzene, maleic anhydride, vinyl chloride, esters of organic acids (like acrylates or methacrylates), unsaturated polyesters, and more. This results in the formation of polymeric materials that possess distinctive properties, making them well-suited for a wide range of industrial applications [4–7].

Polar and non-polar additives, known as plasticizers, are incorporated into plastic materials to enhance their processing, performance, and flexibility. Plasticizer molecules destroy the secondary valence bonds, or van der Waals force, between polymer chains. Consequently, there is a reduction in the intermolecular interactions, leading to enhanced mobility of the polymer chains [8,9]. Consequently, the materials exhibit reduced moduli, stiffness, glass transition temperature, and hardness. Furthermore, the capacity of materials to undergo elongation and exhibit flexibility in polymer chains experienced a substantial increase [10,11,12]. Low-molecular-mass organic compounds are the most often used plasticizers. These compounds have low volatility, which prevents them from evaporating quickly from their constituent products [10].

The most generally used plasticizers for PS in commercial applications are phthalate esters, including dimethyl, diethyl, dipropyl, dibutyl, diheptyl, dioctyl, diisodecyl, and benzylbutyl phthalates [13,14]. Furthermore, the utilization of adipate and glutarate esters as plasticizers for expanded polystyrene, as well as liquid paraffin and zinc stearate as internal plasticizers, has been documented [15,16]. Nevertheless, the majority of phthalates possess toxic characteristics that are harmful to humans. Ongoing research is focused on developing novel materials that are non-toxic and biodegradable and can serve as alternatives to hazardous plasticizers [16,17]. Recently, researchers have been studying the use of environmentally friendly plasticizers, such as epoxidized vegetable oils, biodiesel oils, hydrogenated Castrol oil, citrate esters, low-molecular-weight polyethylene glycol, and core-hydrogenated phthalates [13,18].

Sand apricot (Landolphia kirkii) is an indigenous vine species found in tropical Africa, recognized for its consumable fruits. The seeds of Landolphia kirkii are known to possess oil, which exhibits potential use, such as in traditional medicine or cosmetics [19]. The qualities and applications of this oil are contingent upon its composition, which can differ across various plant species. The sand apricot seed contains a high concentration of nutrients, including lipids, proteins, soluble carbohydrates, and fibres [20]. The oil primarily comprises unsaturated fatty acids, including oleic and linoleic acids [19].

Sand apricot seed has been extensively utilized in traditional oriental medicine to alleviate respiratory symptoms and ailments, including coughing, wheezing, asthma, emphysema, and bronchitis [20]. Furthermore, it has been employed for the treatment of skin ailments such as furuncle, acne vulgaris, and dandruff, as well as constipation [21,22]. Pharmacological research has shown that apricot seeds have antiasthmatic, antiinflammatory, analgesic, antimutagenic, anticancer, antioxidant, and antibacterial properties [23,24]. Regarding the antibacterial properties, both the water and methanol extracts demonstrated inhibitory effects against Staphylococcus aureus, Escherichia coli,

Proteus mirabilis, Salmonella typhi, and Candida albicans [24,25]. Thus, the main objective of this paper is to investigate the mechanical characteristics of polystyrene (PS) when utilizing sand apricot seed oil as a plasticizer.

2. MATERIALS AND METHODS

2.1 Materials

Potassium disulphate, n-hexane, styrene, sand aricot seed oil, methanol, toluene and aluminum sulphate 18-hydrate were from Scharlau Chemie, Hot plate wooden mould (102 cm x 51cm x 63cm), camry emperors weighing balance, S-metlar balance (electronic).

2.2 Sample Collection and Preparation

The sample of dried apricot seeds was obtained from Awgu L.G.A. in Enugu State, Nigeria. The study was conducted in the Department of Industrial Chemistry, Enugu State University of Science and Technology, located in Enugu State, Nigeria. The seeds were dehusked to extract the kernels, which were subsequently dried and ground into a fine powder before being kept in a hermetically sealed plastic container.

2.3 Extraction Procedure

The sand apricot seeds were ground and air-dried to a particle size of approximately 200 g. After weighing and packing them into a thimble, they were placed into a Soxhlet extractor. The 500 cm^3 of standard hexane and the anti-bumping chips were heated on a heating mantle at 70 ◦C in a 1000 cm^3 round bottom flask to remove impurities. The solvent was left to clear before the extraction was stopped. At 40 ◦C, a rotary evaporator was used to collect and dry the solvent in the flask with a round bottom. To get an average percentage of extraction and adequate oil for additional testing, the procedure was repeated [26].

$$\text{Oil content} = \frac{Weight\ of\ the\ oil}{Weight\ of\ sample} \times 100$$

2.4 Specific Gravity of Seed Oil

After recording the mass of an empty, clean, and dry 50 cm^3 density bottle, the mass of the bottle and its contents were measured by filling it with distilled water and then weighing it again. After measuring the weight of each seed oil in its own density bottle, the specific gravity was calculated by adding the combined weight of the bottle and oil [7]:

$$\text{Specific gravity} = \frac{Weight\ of\ oil}{Weight\ of\ Water}$$

2.5 Saponification Value

For each oil sample, 5 cm^3 was measured and added to a volumetric flask along with 50 ml of alcoholic KOH. The mixture was then allowed to drain for 30 minutes. A blank was also made by removing 50 cm3 of alcoholic KOH and letting it drain for 30 minutes. Boiling the flask gradually for around an hour is the plan after connecting it to the air condenser. Once cooled, the condenser was cleaned with a small amount of distilled water and subsequently removed from the flask. Lastly, 1 ml of phenolphthalein was added and the colour would be removed by titrating it against 0.5 millimolar of hydrochloric acid [27].

$$\text{Saponification value} = \frac{(56 \times N(V0 - V1))}{W}$$

Where; V0 = the volume of the solution used for the blank test; V1 = the volume of the solution used for determination; N = actual normality of the HCl used; W = Mass of the sample.

2.6 Acid Value

Exactly 2 cm^3 of oil sample was weighed into a 250 cm^3 conical flask and dissolved in 25 cm^3 of alcohol each. Then, two drops of phenolphthalein indicator were introduced. The contents were titrated with alcoholic potassium hydroxide. Blank titration was carried out with 100 cm^3 of the titration solvent and 0.5 cm^3 of indicator solution. The KOH solution was standardized on a regular basis to detect the 0.0005 molarity change. The volume of 0.1cm^3 KOH (VA) for the sample titration, and volume for the blank (VB), were noted [28].

$$\text{Acid value} = \frac{M \times 56.1}{W}$$

Where; A = Amount (mL) of 0.1M KOH consumed by sample, M= Molarity of KOH, W= weight (g) of oil sample.

2.7 Iodine Value

Exactly 0.4 cm^3 of the oil sample was measured and placed into a conical flask. Subsequently, 20 cm_3 of CCl_4 was introduced to dissolve the oil. After the specified time elapsed, a total of 20 cm^3

of a solution containing 10% KI (10 g dissolved in 100 cm^3 of water) and 125 cm^3 of distilled water were introduced into the mixture using a measuring cylinder. The substance was subjected to titration using 0.1M sodium-thiosulphate solutions until the yellow colour was hardly imperceptible. A small amount of 1% starch indicator was introduced, and the titration will proceed by gradually adding thiosulfate until the blue coloration vanishes upon vigorous agitation. The identical methodology was employed for the blank examination [29,30].

$$\text{Iodine value} = \frac{(12.69 \times C \times (V0 - V1)}{W}$$

C = Concentration of sodium thiosulphate used,
V1 = Volume of sodium thiosulphate used for blank,
V2 = Volume of sodium thiosulphate used for determination,
W =Mass of the sample.

2.8 Polymerization and Plasticization of Polystyrene

Potassium disulphate (2.0 g) was dissolved in 2 ml of water in a 200-ml-capacity beaker and stirred for 6 minutes. A solution of styrene (90 ml) was added to the solution and stirred under heat until there was an observable colour change from transparent to milky at 87 °C. Plasticizer (WPO) was added and continuously stirred until the mixture started becoming viscous at temperatures of 120 ^oC; the viscosity changed colour from milky to brown at 130 ^oC; the solution became more viscous; and plasticity was achieved at 140 ^oC [31]. The formation of polystyrene sheets with SAO plasticizers is illustrated in Table 1.

2.9 Acid Test Resistance

The ASTMD 6137 test technique of the electronic weighing balance was used in weighing the mass of the sample. The samples size was of 3 mm each. The test samples was measured and the findings recorded. They were immerse in trioxonitrate (V) acid for 24 hours and then removed and dried.

2.10 Mechanical Properties

Mechanical properties were examined with a Hounsfield T series universal testing machine, model-H10KT, using ASTM D638 Tensile Test. Stress/strain curves were obtained at an extension speed of 1 mm min-1 and 100 N Load range.

Tensile properties: The tensile test was conducted on the analysed samples using a Zwick Roell testing equipment in accordance with the ASTM D 638 standard. The observations were performed at a consistent velocity of 5 ml/minute under normal atmospheric conditions at a temperature of 23–25°C.The examination involved analysing five specimens from each polystyrene blend. The test findings were averaged and subsequently published.

Shore D hardness: The Shore D hardness of the samples under investigation was determined using a commercially available durometer in accordance with the ASTM D 2240 standard. Each formulation underwent three measurements, and the average hardness value was recorded.

3. RESULTS AND DISCUSSION

3.1 Physiochemical Properties of Apricot Seed Oil

The physicochemical parameters of sand apricot seed oil are shown in Table 2.

The hexane-extracted Apricot seed has an oil content of 9.0%. In a related study, Amos-Tautua and Onigbinde [32] discovered that groundnut and maize had low oil content (10.54% and 6.63%, respectively), whereas soybean had a relatively high oil content (14.51%). Chatepa et al. [33] found that M. oleifera, P. curatellifolia, and A. digitata seeds had high oil content (34.91±0.93, 46.05±0.19, and 31.65±0.44, respectively). Vegetables' low oil content may have an impact on the accessibility and cost-effectiveness of oils and other food products derived from these plants. Sand apricot seed oil has a specific gravity of 0.931. This means SAO has a density less than water but falls with the range of light oil. Based on the density, SAO can be used as solvent, additives in manufacturing, flotation in mining, coolant and lubricant [34].

The acid value of the isolated SAO was determined to be 12.083 ± 0.12. In a comparable investigation, Amos-Tautua and Onigbinde [32] discovered that the acid values for soybean and groundnut were 19.21 and 4.63, respectively. Chatepa et al. [33] reported an acid value of 2.68±0.01 for groundnut and 9.46±0.02 for pigeon peas. The oil's minimal acidity levels suggest a decreased vulnerability to rancidity, a chemical degradation process in which free fatty acids and other deteriorating substances can

negatively impact the oil's taste and scent [35]. Another result of low acid values is improved stability during the processing phase and reduced equipment corrosion. The iodine value of Apricot seed oil was 18.987 ± 0.40, which was lower than the iodine value of castor oil (84.8 gI2/100g) published by Aremu et al. [36], as well as the iodine values of soybean (73.02 gI2/100g) and pigeon pea (69.64± 5.19) reported by Chatepa et al. [26]. The acid value of the oil surpassed the acid value of 1.85 reported by Konuskan et al. [37] for rubber seed. Onoji et al. [23] indicate that this implies the oil will become unstable and prone to rancidity or peroxidation as time passes [38,39].

The iodine value of SAO is measured as 18.987 ± 0.40. The iodine value of palm oil (50-55 g/100g), peanut oil (76-108 g/100g), and lard (45-60g/100g) is higher than this. The low iodine value of SAO indicates a diminished degree of unsaturation, implying that the oil contains a higher proportion of saturated fatty acids [29,35]. Oils with low iodine concentrations often have improved stability and are less prone to oxidation. These characteristics make them very suitable for applications that require stability and resistance to rancidity, such as in the manufacturing of cooking oils and food processing [33,35]. The natural durability of oils with low iodine values prolongs the lifespan of products made from these oils [34].

The stated viscosity of SAO is 85.23 Ns/m2. The viscosity values published by Zahir et al. [40] for soybean oil (35.5±0.073 Ns/m2), palm oil (33.24±0.810 Ns/m2), mustard oil (48.43±0.556 Ns/m2), and bran oil (37.98±0.525 Ns/m2) are higher than the viscosity of the oil being discussed. Utilizing high-viscosity lubricants can enhance the sealing efficacy of specific components, hence preventing leaks and ensuring a suitable barrier between different elements within a system [7,41]. High-viscosity oils are utilized in systems such as shock absorbers or hydraulic cylinders to offer the required resistance to movement, hence aiding in the regulation of speed and the reduction of oscillations [30].

The refractive index of SAO was documented as 1.412. The refractive index of the rice bran oil, as reported by Konuskan et al. [37], was determined to be 1.459, which aligns with our findings. The refractive indices of palm oil (1.44-1.46), rape seed oil (.47-1.48), and safflower oil (1.47-1.48) reported by Saunders et al. [42] were in agreement with those reported on SAO. A higher refractive index leads to an increased level of unsaturation [43]. Optical systems use high refractive index lubricants as fluids to match the refractive index [30]. These fluids aid in aligning the refractive indices of various optical components, hence minimizing reflections at interfaces and optimizing light transmission. High optical efficiency is crucial in areas where it is particularly significant [36,41].

The saponification value of SAO was 283.271 mg KOH/g. In a comparable study, Ivanova et al. [44] documented the saponification value (235–260 mg KOH/g oil) for many commonly used oils and fats derived from both plants and animals, such as sunflower, soybean, rapeseed, swine lard, cattle tallow, and chicken fat. Sani et al. [35] reported a low acidity level of 246 mgKOH/g in Cocos nucifera oil in a comparison analysis. The text as per the research conducted by Sani et al. [35], the saponification value of Apricot seed oil (283.271mgKOH/g) was more than that of Cocos nucifera oil (246 mgKOH/g). The saponification value is crucial in the shampoo and soap sectors as it indicates the presence of oil in the form of traditional triglycerides [29]. A high saponification score indicates that the oil has a greater concentration of fatty acids with lower molecular weights [39]. Fatty acids of lower molecular weights exhibit a greater number of carboxylic acid groups, thereby necessitating a larger quantity of alkali for their saponification. The saponification value is frequently employed to evaluate the length of fatty acid chains in oils [29].

3.2 FTIR Study of Sand Apricot Seed Oil

The FTIR investigation of sand apricot seed oil is recorded in Table 3, with the vibration frequency, functional group and most likely compounds present in SAO revealed.

The FTIR data showed the presence of OH (3896.258 cm^{-1}), N-S (2598.729 cm^{-1}), and N=C=S (2064.996 cm^{-1}). The significant absorption at 1607 cm^{-1} confirms the presence of a double-bond fatty acid in SAO. The peak seen at 2947.443 cm^{-1} corresponds to the methyl group found in the triglyceride of the seed oil [40,45].

Table 1. Formation of polystyrene sheet with plasticizer

SAMPLE NAME	ASO/WPO	Styrene	Initiator
PS-$UCSO_1$	100.00	90	2.0
PS-$UCSO_2$	80.20	90	2.0
PS-$UCSO_3$	60.40	90	2.0
PS-$UCSO_4$	40.60	90	2.0

Table 2. Physiochemical properties of apricot seed oil

	Properties	Values
1	Oil content (%)	9.0
2	Specific gravity (at 25 ^oC)	0.931 ± 0.00
3	Acid value (mg KOH/g)	12.083 ± 0.12
4	Iodine value (g)	18.987 ± 0.40
5	S.V (mg KOH/g)	283.271
6	Viscosity (mm/s0)	85.23
8	Refractive index	1.412

Table 3. FTIR of sand apricot seed oil analysis

Wave number (cm^{-1})	Peak intensity	Peak shape	Bond	Compound
1382.495	Medium	Broad	O-H bending	Alcohol, Phenol
1607.612	Medium	Sharp	C=C stretching	Cyclic alkene
2064.996	Huge	Broad	N=C=S stretching	isothiocyanate
2450.856	Strong	Sharp	P-H stretching	Phosphine
2598.729	Medium	Sharp	S-H stretching	Thiol
2947.443	Medium	Broad	CH stretching	Methyl
3896.258	Strong	Sharp	O-H stretching	Free alcohol

3.3 Stability of PS-SAO in Acid

The acid resistance of polystyrene with sand apricot seed oil was estimated and compared with that of polystyrene without plasticizer and paraffin oil plasticizer. Table 4 shows the data on the acid resistance of polystyrene with paraffin oil and SAO, tested for 24 hours in troxonitrate (V) acid.

The data in Table 3 revealed the mass of polystyrene plasticizer before and after immersion in acid. The polystyrene with paraffin oil recorded a mass difference of 0.224 in acid, while the polystyrene with SAO plasticizer recorded a mass difference of 0.029. The degradation of polystyrene in the presence of strong acids typically involves chemical reactions that break down the polymer chain [17, 46]. The acidic conditions can lead to hydrolysis, where the ester bonds in the polystyrene backbone are cleaved, resulting in the formation of smaller molecules [35]. This process can cause the degradation of the material, leading to a loss of mechanical strength and other properties [16,18]. Polystyrene with SAO is more stable in acid than that of paraffin oil plasticizer.

3.4 Mechanical Properties of PS-SAO Blends

The mechanical properties of polystyrene with sands apricot seed oil and white petroleum oil are illustrated in Table 5.

The polystyrene polymer blended with sand apricot seed oil (PS-SAO_1) exhibited an ultimate tensile strength (UTS) of 58.6 MPa, whereas the polystyrene blended with white petroleum oil (PS-WPO_1) demonstrated a UTS of 50.6 MPa, both with a plasticizer mass of 100g. The findings indicate that the ultimate tensile strength (UTS) of both PS-SAO and PS-WPO increases proportionally with the mass of the plasticizer. Fig. 1a depicts the correlation between the ultimate tensile strength (UTS) of PS-SAO and PS-WPO. With a plasticizer content of 44.6g, the ultimate tensile strength (UTS) of the polystyrene was the same. However, after this point, the UTS of the SAO exceeded that of the WPO for all mass values. PS-SAO's higher ultimate tensile

strength (UTS) implies its potential for designing structural elements in civil engineering, mechanical engineering components, and medical applications such as orthopaedic implants [47]. Reza-Barzegari [48] observed a significant increase in the ultimate tensile strength of densely packed polystyrene when combined with lignin. In a related study, Das et al. [47] found that blends of unsaturated polyester resin, styrene, and tung oil had better mechanical properties and impact strengths.

The Young modulus of PS-SAO and PS-WPO were 1797.9 and 1954.0, respectively, when the mass of the plasticizers was 40.60g. The Young's modulus exhibited a rise to 1996.1 MPa when the mass of plasticizers was augmented to 100g. The conversation in Fig. 1b demonstrates the correlation between the mass of the plasticizer and the Young modulus. The Young moduli of PS-SAO and PS-WPO were 1954 MPa, 1874.4 MPa, and 1996.4 MPa, corresponding to weights of 60.4g, 82.2g, and 100g, respectively. This indicates that for the specified masses, both PS-SAO and PS-WPO have achieved similar stiffness. A high Young's modulus signifies significant rigidity and minimal deformation under elastic stresses. The addition of plasticizer resulted in enhanced rigidity of the polystyrene polymer blend [27,40]. The percentage elongation of $PS\text{-}SAO_1$ was measured at 13.4%, whereas that of $PS\text{-}WPO_1$ was approximated at 12.6% when using a plasticizer mass of 100g.

The percentage elongation of the polystyrene has a positive correlation with the decrease in mass of plasticizers. Fig. 1c depicts the correlation between the percentage elongation of PS-SAO and PS-WPO. The results are consistent with the findings reported by Garcia-Garcia et al. [49], who observed a notable enhancement in the percentage of elongation and enhanced mechanical properties of poly (3-hydroxybutyrate). Mishra & Naik [50] conducted a comparable study and reported Young's modulus values of 12264 Mpa and 446 MPa for composites made of banana fibre and polystyrene. The table provided, Table 4, presents the break load of polystyrene under varying quantities of plasticizer, specifically SAO and WPO.

The $PS\text{-}SAO_1$ and $PS\text{-}WPO_1$ samples exhibited the largest break loads, measuring 500.6 N and 400.4 N, respectively. Additionally, the break load of the polystyrene blend rose proportionally with the amount of plasticizer used, as seen in Fig. 1d. The maximum peak loads for $PS\text{-}SAO_1$

Table 4. Acid test resistance

S/N	SAMPLES	MASS (g)	Stability
1	Polystyrene without plasticizer	1.224	0.087
2	After immersion in acid	1.137	
3	Ps with paraffin oil as plasticizer	1.756	0.224
4	After immersion in an acid	1.532	
5	PS with sand apricot seed oil	0.383	0.029
6	After immersion	0.354	

Table 5. Mechanical properties of polystyrene blended with petroleum and sand apricot seed oil

Blends	UTS (Mpa)	Young modulus (mpa)	%elongation	Break load (N)	Peak load (N)	Shore D hardness
$PS\text{-}SAO_1$	58.6	1996.1	13.4	500.6	586.7	80.0
$PS\text{-}SAO_2$	55.2	1878.4	21.1	419.8	552.5	78.2
$PS\text{-}SAO_3$	44.0	1954.0	39.5	317.9	440.7	74.4
$PS\text{-}SAO_4$	41.9	1797.9	54.2	311.2	419.4	72.4
Ps- WSO_1	50.6	1996.1	12.6	400.4	603.7	83.0
$PS\text{-}WPO_2$	48.6	1985.3	18.1(69.8)	398.8	552.5	78.2
$PS\text{-}WPO_3$	46.4	1887.8	22.1(286.1)	356.9	500.3	74.4
$PS\text{-}WPO_4$	45.3	1954.0(52)	30.4	317.9	440.7	73.7

UTS= ultimate tensile strength; PS=polysterine; WPO= white petroleum oil; SAO= Sand apricot seed oil

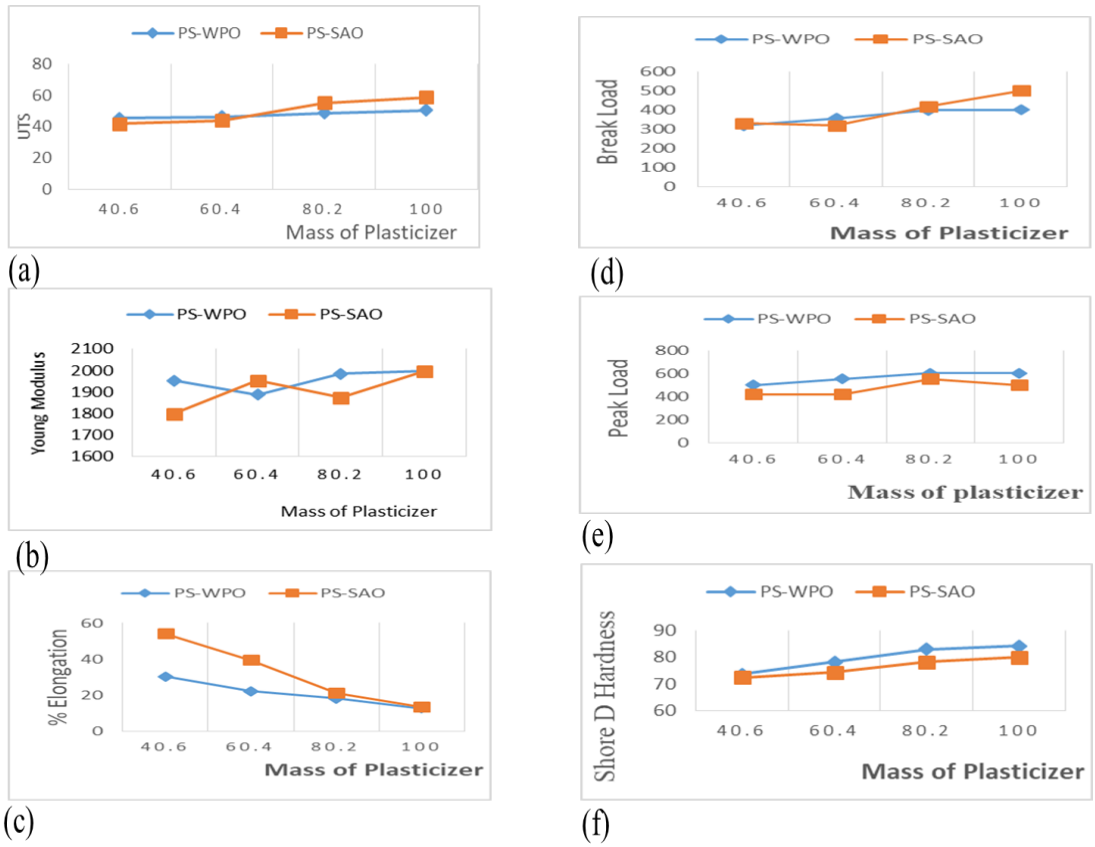

Fig. 1. Mechanical Properties of PS-SAO blends (a) UTS (b) Young modulus (c) % elongation (d) Break load (e) Peak load (f) share D hardness

and PS-WPO_1 were measured at 586.7 N and 603.7 N, respectively. These records suggested that PS-WPO_1 would have a somewhat higher load-bearing capacity than PS-SAO_1. Fig. 1e demonstrates a positive correlation between the amount of plasticizers and the peak load of the polystyrene, indicating that an increase in plasticizers results in a higher peak load. Polystyrene polymers exhibiting a low peak load may possess increased brittleness and a reduced capacity to endure substantial stresses [40,50]. They are appropriate for applications that demand minimal strength and may not be optimal for instances where durability and resistance to mechanical stress are essential [44,45].

The results indicated that PS-SAO_1 and PS-WPO_1 exhibited the greatest shore D hardness values of 80.0 and 83.0, respectively (Fig. 1e and Table 4). The elevated Shore D hardness of polystyrene suggests that the material possesses a considerable degree of rigidity and is highly resistant to indentation [41,49]. The PS-SAO_1 and PS-WPO_1 polymers exhibit greater hardness and reduced flexibility. This attribute is advantageous in situations where the substance must retain its form and withstand distortion when subjected to a load. PS-SAO_1 and PS-WPO_1 can be utilized in applications such as hard packaging, durable containers, or structural components that necessitate a significant degree of rigidity [48].

4. CONCLUSION

The study on the synthesis and physico-mechanical characterization of polystyrene derived from sand apricot seed oil (SAO) employed as a plasticizer reveals the significance of sand apricot seed oil in polystyrene production. The oil quality examination showed a high saponification value, indicating that SAO is acceptable for soap manufacture. Also, the viscosity of 85.23 Ns/m^2 indicated that the can be used to improve the sealing of certain components, prevent leaks and maintain a proper barrier between different elements in a system.

The FTIR confirmed the presence of double bond, isothiocyanate, phosphine and thiol and methyl, based on the vibration frequency. The acid resistant test with HNO_3 show that PS-SAO is stable in strong acid.

Sand apricot seed oil plasticizer was found to improve the mechanical qualities polystyrene particularly in the domains of ultimate tensile strength, Young modulus, break load peak load, and shore D hardness. However, the % elongation of the PS-SAO decrease as the concentration of the plasticizer increases. According to the results, the polystyrene with UCSO as a plasticizer exhibits favourable mechanical qualities suitable for packing, characterized by durability and a high level of suitability. The discoveries will enable engineers, researchers, and manufacturers to make informed decisions that improve the overall performance, reliability, and safety of products built from polystyrene.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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