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Research Article

Preparation and characterization of potato crust-based polyurethane Foam-II

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ABSTRACT

In this research study, environmentally friendly and biodegradable PU polymer foam was synthesized from starch-containing potato crust to be used as a thermal insulation material by reducing reliance on fossil resources and utilizing biomass resources. Biopolyols were obtained by reacting with active solvents at different reaction times, in the presence of different catalysts and at different catalyst concentrations. The most suitable polyol in terms of biomass content, density, viscosity and acid-hydroxyl number was selected for PU foam synthesis. Reactions for PU synthesis were tried and PU foam was synthesized. The synthesized PU foam was examined by Scanning Electron Microscope (SEM) and Thermo Gravimetric Analysis (TGA). Its morphological structure, thermal degradation properties, sound transmission coefficient and water absorption properties were determined by comparing it with a commercial PU foam. SEM images showed a heterogeneous pore distribution with closed and open cells, the majority of which were closed. From the TGA results, it was determined that a two-step degradation occurred and incorporating biomass into its structure improved the total thermal degradation properties. The sound transmission rate of starch-containing PU foam, when used as a thermal insulation material, was measured to be lower than the concrete structure, but partially close to and higher than that of commercial PU foam. The water absorption properties of the synthesized PU foam were found to be significantly higher compared to commercial PU foam and contributed to its usability as a thermal insulation material. Thermal insulation material PU foam is synthesized in terms of its properties.

Keywords: Potato crust, liquefaction, polyurethane foam, characterization

1. INTRODUCTION

Polyurethane foams can be assumed to be composite structures that result in a controlled trapping of gases produced during the polymerization reaction between polyfunctional alcohols and polyisocyanates to form urethane link chains.[1,2] Polyurethanes are polymer derivatives formed as a result of the reaction between polyols and isocyanates in determined ratios and conditions, according to their desired properties, and they have -N-(C=O)-O- carbamate chemical bonds in their structure.[3] It is used in the preparation of more than a thousand materials in the building, construction and material sectors. Its components include (1) polyols, (2) isocyanates, (3) catalysts, (4) silicones, (5) special auxiliary additives.[4] The physical and mechanical properties of polyurethanes are determined by their chemical composition. Their chemical composition determines the physical and mechanical properties of polyurethanes. According to this; rigid, flexible, semi-flexible, elastomer and spray PU foam types are available.[4] Polyurethane types are determined by the percentages of OH (hydroxyl) and NCO (urethane) in their components. The number of OHs is more than 300 in hard foams and 100 in semi-rigid foams.[5] Catalysts are compounds that increase the reaction rate by causing chemical reactions to proceed through another

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mechanism with lower activation energy. Each chemical reaction has its own characteristics and is synthesized or determined through experimental studies. This phenomenon is called Catalyst Selectivity. The ratio of the rate constant of a chemical reaction carried out with a catalyst to the rate constant to carried out without a catalyst is called Catalyst Activity.[6]

If biomass-containing polymer is synthesized during PU synthesis, the catalyst is used both during biopolyol synthesis and PU synthesis. On the other hand, if PU synthesis is provided only from petroleum subproducts, the catalyst is used in a single polymerization reaction. As a result of our literature review, it was seen that both acid catalysts [7-12] and alkaline catalysts[13,14] were used during biopolyol synthesis. The use of alkaline catalysts is less in the current literature. The most commonly used catalysts are sulfuric acid and phosphoric acid, while the basic catalyst is sodium hydroxide. It was determined that the acid catalyst activity was lower than that of the basic catalyst under the same reaction conditions.[15,16] On the other hand, basic catalysts have the advantage that they cause less corrosion in the reaction equipment.

Fidan and Ertaş [17] reported that the prepolymer reaction rate of the formation of apricot kernel polyol at the same temperature and time increased with increasing catalyst concentration. The liquefaction content was measured as 93.5%, 96.7% and 96.7%, respectively, at 5%, 7%, 9% acid catalyst concentration under conditions of Biomass/PEG400-Glycerol w/w 1/3, temperature 160ºC, t = 2 hours. Increasing catalyst concentration caused the viscosity and OH number of the biopolyol to decrease. Again, in the environment of high catalyst concentration, biomass condensation was observed.

Norouzi et al.[18] used green microalgae as biomass in the synthesis of polyurethane composites and carried out the polymerization reaction in the presence of three different graphene oxide catalysts to which they attached methylene, vinyl and amine groups. As a result of the polymerization reaction, vinyl-bonded graphene oxide catalyst activity was determined to be the highest. This situation is attributed to the vinyl catalyst's (1) fixed and accessible Bronsted acid sites, (2) physical hybrid structure of graphene oxide, and (3) higher number of polymerization reagents on the catalyst surface.

Zhang et al.[7] determined that in the liquefaction process carried out at 3% sulfuric acid catalyst concentration, where the polyol/biomass was w/w 5/1, the amount of residue first decreased and then increased with increasing reaction temperature and reaction time. This is attributed to the occurrence of recondensation in the liquefaction of the corn cob. Hasan and Shukry (2000)[8] observed that in polyol polymer reactions involving bagasse and cotton stalk biomass, the amount of residue at the end of the reaction decreased with increasing acid catalyst concentration under the same conditions, and there was no condensation at acid catalyst concentration higher than 5%. In our experimental studies, the synthesis and identification of starch-potato biopolyol and its usability as a PU thermal insulation material were investigated.

2. EXPERIMENT

2.1. Materials

Potato crusts were dried under atmospheric pressure. The plant residue was ground with a Warning Commercial Blender model (Warning Product Division Comp., New Hartford-U.S.A). Potato crust meal (Solanum Tuberosum L., 177 micron) was dried again for 12 hours in an oven (FN-120 Model Nüve Dry Heat Sterilizer (Germany)) at 103 ± 2 ºC before being put into the reaction. Polyethylene glycol # 400 (PEG#400, Merck Company/Germany), glycerin (Merck Company /Germany), sulfuric acid, hydrochloric acid, phosphoric acid and sodium hydroxide were supplied from commercial company (Sezlab Chemical Mate. Paint Ind. Commence Ltd. Company). Other ingredients included polymeric diphenylmethane diisocyanate (PMDI 92140), triethylenediamine catalyst (93040), silicone surfactant (Silicone Glycol Copolymer, Chemika 81.170, M_A=380g.mol^{-1}), silicone PEG #400 were used as received. Water was used as the foaming agent. Scaltex SBA 53 Model precision scale was used in all necessary stages of our research study.

2.2. Ash test and elemental analysis

Ash Test of biomass was carried out according to the E1755-01 Standard Method by a Nüve MF 120 Model (Germany) device. Organic elemental analysis of potato crust was performed with a Thermo Scientific Flash 2000 CHNS-O Analyzer with a reactor temperature of 950 ºC.

2.3. Preparation of biopolyols

PEG#400/Glycerin 4/1 w/w reagents were used as solvent for the first step polymerization process (liquefaction). H_2SO_4, HCl and H_3PO_4 were preferred as catalysts. The polymerization reactions were carried out with the total equipment of a microwave heating oven (Neos brand) with an independent backcooling system and a dependent temperature sensor.

The process decided for the biomass liquefaction polymer reaction is as follows; biomass/PEG#400/Glycerol 5/12/3 w/w/w 500 ml N/S 500 ml glass flask was placed. For each reaction, 3-21% x total amount of solvent was added separately and premixed.

A normal heating program of 350 watts/minute and a stirring speed of 300 rpm were found sufficient for the reactions. The reagents were left to react separately for 15 and 30 minutes. It was allowed to cool for half an hour and the acid catalyst in it, was neutralized with sodium hydroxide solution (40% w/w).

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2.4. Measurements of the un-liquefied potato crust parts

About 4 g. of the liquefied mixture was dissolved in 10 ml of methanol solvent and then dilution was filtrated through glass filter paper under reduced pressure by water type vacuum pump (TVP 200 Model). The solid residues were dried in an oven at 103 ± 2 ºC to a constant weight and the residue percent of the potato components (the residual contents in the liquefied components-based polyols) was calculated by the following equation (Eq. 1):

$$R(\%) = \left(\frac{m_1}{m_0} \right) x100 \qquad (1)$$

where, R is the residual rate in percent (%), m_1 is oven-dry weight of the solid potato component residue (g), m_0 is oven-dry weight of the starting potato component meal (g).

2.5. Measurements of the specific gravity, apparent viscosity and surface tension of the liquefied potato crust-based polyols

The solvent in the liquefied biomass was removed with a Heidolp Laborota 4000 Efficient model fractional distillation device. The specific gravity of the liquefied potato components-based polyols was measured according to ASTM 4669. The apparent viscosity of the liquefied potato components-based polyols was measured by a Brookfield DV-I Viscometer with S05 spindle by 50 rpm/min mixing speed rate according to ASTM D 4878. Surface tension of the liquefied polyols measured according to Pendant Drop Method. Measurements were conducted at 25 ± 2 ºC.

2.6. Measurement of the acid number of the biopolyols

The acid number of the biopolyols was measured by the titration method according to ASTM D 4662-08.

2.7. Total acid value

The acid value of biopolyols was determined as follows.
1. Ethyl alcohol (120 mL) and toluene (120 mL) are mixed in a total 240 mL flask (Reagent).

2. Indicator; it consists of mixing 0.5 g of phenolphthalein in a mixture of 50 mL of ethyl alcohol and 50 mL of pure water.

3. For 0.1N KOH; it is prepared by adding 10 mL of water, 5.61 g of KOH and the remaining ethyl alcohol in a 1000 mL flask.

4. 40% (w/w) NaOH solution is required for the neutralization process. Prepare 40 g of NaOH by completing the volume to 100 mL with pure water.

5. 40% (w/w) solution containing an equivalent gram of NaOH equal to the equivalent gram of acid catalyst in the liquefied sample is added to the liquefied sample and mixed well with the help of a baguette.

6. The process is carried out by taking 0.5 g of liquefied polyol, previously neutralized, with 25 mL of reagent. Then, 0.25 mL of indicator is dropped into this mixture, then 0.1 N KOH placed in the burette continues to be added until a color change is observed (The volume used is then noted down, this is the A value in the formula).

7. After adding 0.25 mL of indicator to 25 mL of reagent, titration is performed with 0.1 N KOH (The amount of KOH spent is recorded, it is the B value in the formula). As a result, the acid value is calculated according to the formula below.

$$AD = \frac{(A - B)\text{x}N\text{x}56{,}1}{W} \quad \text{mg KOH/g polyol} \qquad (3)$$

2.8. Measurements of the Hydroxyl Numbers of the Biolyols

The hydroxyl number of biopolyols was measured according to ASTM D 4274-05.

2.9. Total Hydroxyl Value

The hydroxyl value of the biopolyols was determined as follows.
1. Prepare 0.5 M NaOH from a mixture of two 2 g NaOH and 100 mL of pure water.
2. Seven hundred (700) mL pridine and 111 g phthalic anhydride are mixed with the help of a magnet at 110° C for 2 hours (in a dark colored balloon). (reagent)

3. For the indicator; A mixture of 50 mL of pyridine and 0.5 g of phenolphthalein is required.

4. Forty percent (40%) NaOH solution is required for the neutralization process (40 g NaOH is prepared by making up its volume to 100 mL with pure water.

5. 40% (w/w) solution containing an equivalent gram of NaOH equal to the equivalent gram of acid catalyst in the liquefied sample is added to the liquefied sample and mixed well with the help of a baguette.

6. After adding 0.25 mL of phenolphthalein to 25 mL of reagent, it is titrated with 0.5 M NaOH (aqueous) (The volume of NaOH spent is recorded and is the A value in this formula).

7. The procedure is carried out by taking 0.5 g of sample with 25 mL of reagent. Then, 0.25 mL of indicator is dropped into this mixture and the addition is continued until a color change is observed with 0.5 N NaOH solution placed in the burette (Then the volume used is noted and it is the B value in the formula).

As a result, the hydroxyl number is calculated according to the formula below.

$$HD = \frac{(B-A).N.56.1}{w} \quad \text{mg KOH/g polyol} \qquad (4)$$

2.10.Preparation of the PU foams

After the acid catalyst contained in the synthesized biopolyols is neutralized, it is used for the PU foam reaction. Biopolyol, catalyst, surfactant and water were used as reagents in the second polymerization reaction. The pH value at which the second step polymerization reaction was carried out was determined with the Model PHSJ-3F pH meter. Tried and preferred formulations were applied. Pre-mixing was done in a plastic container and MDI (isocyanate index 90) was added and mixed rapidly for 15-20 seconds at a high mixing speed of 8000 rpm. Ultra-Turrax T8 IKA Labor Teknik mixer device was used in the PU foam synthesis process. It was allowed to rise freely under room conditions. The crystal structure of the foams was waited for two days to settle within itself. They were then removed from the plastic container and cut to be used as test samples.

Table 1. Foam formulations for the biyopolyol-contained PU foam

	Ingredients	Parts by Weight
1. Liquid	Biopolyol	100
	Catalyst	3
	Surfactant	2.5
	Blowing agent	6.25
	PEG 400	20
2. Liquid	MDI	130

2.11.Scanning Electron Microscopy (SEM)

The cell morphology of starch-based polyurethane foam was observed by Zeiss mark, EVOLS 10 model (Germany) Scanning Electron Microscopy (SEM) with an accelerating voltage of 20.0 kV. Samples were cut in the form of thin partition and the partition surfaces were sputtered by a Ressina Ton mark, 108 Auto model sputtered coater with Au and then observed.

2.12.Thermal gravimetric analysis of foam

Thermal Gravimetric Analysis (TGA) was carried out at a heating rate of 10 ºC/min from 25 to 800 ºC under 100 ml/min nitrogen flow speed using SHIMADZU TA-60WS model Thermo Gravimetric Analyzer.

2.13.Sound conduction speed of foams

Sound conduction speed was measured by Pundit Sound Conduction Instrument (CNS Farnell Model) according to ASTM C-597.

2.14.Water intake test of biyopolyol-contained pu foam

Synthesized biomass-containing PU foam samples and commercial petroleum-derived PU foam samples were cut into cubes and triple test samples. Biomass-containing PU and comparison material commercial PU foams were soaked in water for 7 different periods of time. After removing the coarse water drops on the surface, measurements were taken in accordance with the equation below (Equation 5).

$$Water \;\; absorption = \frac{W_S - W_0}{W_0} X \; 100 \qquad (5)$$

In the equation, W_0 is the initial mass (g) of the PU foam and W_s is the mass of the PU foam after water absorption.

3.RESULTS AND DISCUSSION

3.1.Ash test and elemental analysis

Ash content of potato crust and potato vine were found about 6.56% and 16.41%, respectively. According to the results of the elemental analysis, the N, C, H and protein ratios of the potato crust were determined as 2.345%, 40.791, 6.015 and 14.65%, respectively and a total of 49.151%.

3.2.Effect of reaction time on liquefaction

The goal of the liquefaction was to corporate starch-contained solid potato crust into the liquid polyols with microwave heating method. Table 2 presents the effect of liquefaction conditions on the liquefaction reaction.

Table 2 shows that at 9% sulfuric acid catalyst, residue is 4.88% at the end of 15 min, 0.6% at the end of 30 min. At 4% sulfuric acid catalyst concentration, residue is 6.04% at 15 min and 4.70% at 30 min. Once again, at 3% sulfuric acid catalyst, residue is 9.25% at 15 min and 5.74% at 30 min. In respect of microwave heating and potato structure, potato crust was sustained to liquefaction rapidly and as a result, residue percent decreased over time. It is clearly seen that significant part of liquefaction was occurred in the initial periods of reaction and the residue percent descended slowly at the later stages of the liquefaction. [17]

3.3.Investigation of completion temperature of liquefaction reaction

Table 2 shows the liquefaction reaction completion temperatures of potato crust components in PEG 400/Glycerin binary solution by microwave heating method. This indicates that potato crust was liquefied by microwave heating at the range of temperature between 75 to 100 ºC. In addition, when concentration of the catalyst decreased, the temperature of the liquefaction reaction also decreased. In all the liquefaction process, re-polymerization did not occur. In other words, the liquefaction reaction is mostly not some kind of equilibrium reaction. For almost all potato crust liquefaction, 350 watt/min energy with 300/min rpm mixing speed at 9% organic acid concentration and 100°C degree temperature was sufficient.

Table 2. Effects of the reaction conditions on liquefaction reactions.

Catalyst	**%Sulfuric acid concentration**	**Reaction time (min)**	**PPIP (%)**	**Reaction Completion Temparature (°C)**
H_2SO_4	3	15	9.25	86.6
H_2SO_4	4	15	6.04	78.2
H_2SO_4	9	15	4.88	90.3
H_2SO_4	3	30	5.74	94.2
H_2SO_4	4	30	4.70	100.4
H_2SO_4	9	30	0.60	107.0
$H_2C_2O_4.2H_2O$	9	15	74.45	121.6
$H_2C_2O_4.2H_2O$	12	15	83.25	119.4
$H_2C_2O_4.2H_2O$	18	15	84.60	133.0
$H_2C_2O_4.2H_2O$	9	30	94.92	125.2
$H_2C_2O_4.2H_2O$	12	30	83.20	105.6
$H_2C_2O_4.2H_2O$	18	30	74.85	118.3
HNO_3	6	30	79.90	172.4
HNO_3	9	30	73.50	144.3
HNO_3	12	30	71.60	103.2
CH_3COOH	12	15	3.425	146.1
CH_3COOH	15	15	5.73	137.8
CH_3COOH	18	15	14.40	127.5
CH_3COOH	12	30	1.06	165.2
CH_3COOH	15	30	1.94	142.9
CH_3COOH	18	30	9.164	118.3

Conditions: Biomass/PEG400/Glycerin = 5/12/3, 350 watt/min microwave-heating energy, 300 rpm/min mixing speed; PDIP (Percent of PEG#400 insoluable part)

Effect of Catalysts Strain on the Liquefaction

In the experiments, sulfuric acid, oxalic acid dihydrate, acetic acid and nitric acid were added as the catalyst of the liquefaction reaction 3% to 18% under microwave heating within 15 and 30 min. At 9% sulfuric acid, oxalic acid dihydrate and nitric acid catalyst ratio, residue percentages of potato crust were 0.6, 84.30 and 73.50 within 30 min, respectively. As seen in Table 2, re-condensation took place by using oxalic acid dihydrate, and nitric acid catalyst, as the catalytic activity of these catalysts was not sufficient for this reaction. In addition, this condition attributed to the decrescent of catalytic activity of the catalyst by excess the water content of the catalyst.[18] Again, the low catalytic activity of acetic acid under these reaction conditions where we carried out the liquefaction reactions is attributed to the fact that it is a weak acid.[19-21]

Effect of Catalyst Concentration on Liquefaction

Table 2 shows that with incremental of organic acid concentration, quantitative of liquefied potato crust was increasing. For almost all liquefaction ratio, 9% sulfuric acid concentration is enough and appropriate for practical applications. In addition, about 9% sulfuric acid catalyst is enough to obtain complete liquefactions, even if the content of starch-based potato crust is up to 25% (based on the weight of the total mixtures without catalyst).[22]

Characteristic Properties of Potato Crust-Based Polyols

Table 3 shows the characteristic properties of liquefied starch-contained potato crust polyols. As seen in Table 3, specific gravity of potato-crust based polyols increased with liquefaction ratio. In contrast to those of biomass-based polyols, specific gravity is similar greatness.

Potato crust-based polyols did not contain residue component therefore viscosity was decreased with the decrescent liquefaction ratio. However, measurements were unable to be carried out roboustly by virtue of polyol's great viscous. The surface tension of the polyols decrease with the decrescent liquefaction ratio. Potato crust-based polyols which were produced by 9% sulfuric acid catalyst concentration within 15 and 30 min have 412 and 407,9 hydroxyl value respectively. This phenomenon can be explained by realizing of liquefaction reaction mainly in the early stages of reaction, as hydroxyl value decreased rapidly.[23] When the potato crust was completely dissolved, it indicates that the hydroxyl groups of the potato crust were liberated by liquefaction and dissolution.[24]

Table 3. Properties of the liquefied biyopolyols.

Catalyst	**Organic acid concentration [%]**	**Reaction Time [min]**	**Apparent Density [g/cm^3]^a**	**Viscosity [Cp]^a**	**Surface Tension [dyn /cm]^a**	**Acid Value [mg KOH/g]**	**Hydroxyl Value [mg KOH/g]**
H_2SO_4	3	15	1.32	586	218.7	38.9	385.8
H_2SO_4	4	15	1.34	589	223.7	40.0	388.0
H_2SO_4	9	15	1.35	744	347.6	43.8	407.9
H_2SO_4	3	30	1.16	877	193.9	33.4	372.5
H_2SO_4	4	30	1.21	880	199.5	43.7	381.8
H_2SO_4	9	30	1.26	893	334.2	50.3	412.0
$H_2C_2O_4.2H_2O$	9	15	1.18	358	161.3	18.7	447.1
$H_2C_2O_4.2H_2O$	12	15	1.21	314	158.8	29.7	313.5
$H_2C_2O_4.2H_2O$	18	15	1.31	300	186.4	32.1	390.2
$H_2C_2O_4.2H_2O$	9	30	1.13	390	163.4	33.0	280.5
$H_2C_2O_4.2H_2O$	12	30	1.29	374	166.9	30.5	380.0
$H_2C_2O_4.2H_2O$	18	30	1.36	496	245.5	20.0	450.4
HNO_3	6	30	1.29	580	140.2	24.9	287.9
HNO_3	9	30	1.31	604	183.9	20.7	352.8
HNO_3	12	30	1.37	682	224.3	19.3	422.5
CH_3COOH	12	15	1.06	337	90.65	7.1	38.9
CH_3COOH	15	15	1.07	324	65.77	6.3	62.7
CH_3COOH	18	15	1.07	290	55.91	5.6	90.7
CH_3COOH	12	30	1.17	564	79.02	23.6	105.1
CH_3COOH	15	30	1.19	580	69.46	5.1	59.6
CH_3COOH	18	30	1.19	720	63.5	5.0	41.3
PEG 400	-	-	1.12	140	-	-	280

Table 4. Characteristic and mechanical properties of foams.

Polyurethane Foam	**Cell Size [µm]**	**Cell Structure Distribution**	**Initial Thermal Degradation [°C]**	**Thermal Degradation 50% of mass [%]**	**Residue after Thermal Degradation [%]**	**Sound Conduction Speed [km/s]**
Biomass/PEG# 400/Gycerin 5/12/3 9% sulfuric acid t: 30 min	300.4	Heterogeneous	388.0	423	0.608	0.801
Synthetic Foam	371.0	Heterogeneous	292.6	362	0.126	0.675

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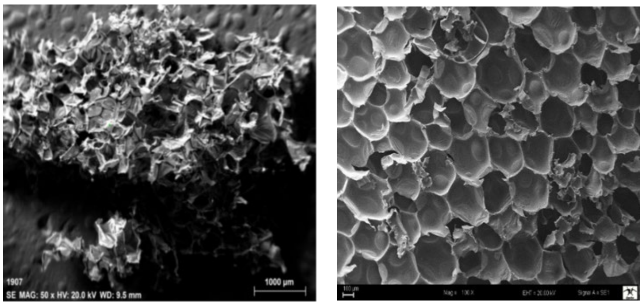
Characteristic and Mechanic Properties of Potato PU Foams

The liquefied potato crust at least residue ration which was produced by 9% sulfuric acid catalyst within 30 min was chosen to prepare polyurethane foam by reaction with methylene diphenyl diisocyanate (MDI).

Scanning Electron Microscopy Analysis of PU Foams

Surface morphology analysis of the potato crust-based PU foams was revealed by the Scanning Electron Microscopy (SEM) (Figure 1).



(a) (b)

Figure 1. SEM images of biomass-based PU foams (a) and petroleum-based PU foams (b).

PUFs prepared from %25 of liquefied potato crust polyol-based on PEG400 and glycerol polyol, showed almost smooth surface, well-defined cell wall and the pore diameter varied in the range between 286.2 and 314.6 µm (mean pore diameter 300.4 µm). However, the liquefied potato crust-based PU foams has less heterogeneous surface and irregular pore shape than those of other biomass-based PU foams.[25-27] In addition to these, pore diameter of syntetic foam specimens varied in the range between 357.3 and 384.7 µm (mean pore diameter 371.0 µm) and slightly less heterogeneous surface was observed.[25,28]

The hypothesis of the open-cell structure is not confirmed principally by the morphological analysis performed by the Scanning Electron Microscopy because both of open and closed cell structure were observed as reported by Ugarte and Hakim. Figure 1, relating to a foam of composition Potato Crust/PEG400/Glycerol, is representative of the typical morphology of these foams. Foams showed a homogeneous structure without evidence of gross phase separation.

Thermal gravimetric analysis (TGA) of PU foams

In thermal gravimetric analysis, initial thermal degradation temperature of potato crust-based polyurethane foam was 388 ºC, degradation temperature half of mass was 423 ºC, thermal degradation completion temperature was as to 522 ºC degree. The residue at 800 ºC was 6.08%. By comparison with synthetic foams, the initial degradation temperature was 292.6ºC, degradation temperature half of mass was 362ºC, thermal degradation completion temperature was 499.6ºC, and the residue at 800ºC was 12.67%.

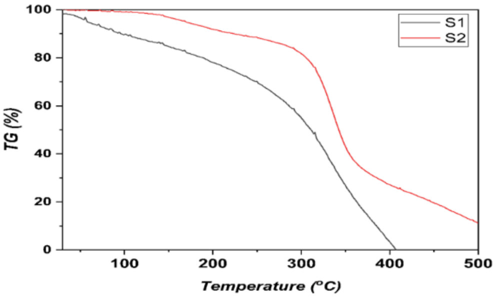


Figure 2. TGA thermograms of biomass-based PU foam (S1) and synthetic PU foam (S2).

Based on these results, it was suggested that the foams made from the potato crust-based polyols had higher initial degradation temperature with improved thermal degradation properties due to prolonged thermal degradation period, as reported by Hakim et al.[28] than those derived from the fossil-based polyols.

Sound Conduction Speed of PU Foams

Sound conduction speed of foams prepared from liquefied potato crust polyols was 0.780 km/h. By comparison to the foams prepared from the fossil-based polyols, it was 0.67 km/h. The sound conduction speed was partially high, but close than synthetic foams.[29]

Water Intake Test for PU Foams

The average water absorption amounts of PU foam samples with starch main composition and cellulose side composition were measured as 137%, 156%, 226%, 249%, 393%, 608%, 1.030% in 1, 2, 4, 8, 12, 24 and 48 hours, respectively. These numerical datas are 35%, 42%, 52%, 65%, 76%, 84% and 89% in our commercial comparison samples. This is attributed to the hydrophilic character of the natural components of starch and cellulose in the biomass structure and the improved surface structure and increased bonding points when added to the structure of the PU polymer. With these properties, they can be used as moisture-absorbing thermal insulation materials, absorbent product manufacturing, and adsorbents in agriculture and horticulture.[27,30,31]

CONCLUSIONS

As a result of our experimental studies, potato crust, one of the agricultural wastes, were transformed into biopolyols by microwave heating method with binary solvents and different catalysts. In our synthesis processes where the microwave heating method was used, a higher reaction rate was achieved at lower temperatures. This is attributed to the homogeneous distribution of the amount of heat reaching the reaction vessel from all sides of the method used and the contribution of the equipment installed simultaneously in the device. When the literature is reviewed in the relevant field, the number of biopolyol synthesis studies using different acid catalysts is quite limited. In this respect, our scientific article will provide significant benefits in terms of catalytic activity to biopolyol synthesis processes, both with different catalysts and different catalyst concentrations. It is very striking here that; excessive water content of catalysis reagent has influenced to their catalytic activity.

Thermal analysis performed for PU material showed that combining biomass with petroleum product polyols increases the average combustion temperature and reduces the amount of residue remaining as a result of the combustion process. Again, as a result of morphological analysis, it was observed that the cell structure was formed and the majority of it was composed of closed cells. The closed/open cell number ratio is lower than in our comparison sample, but the biological properties it brings to the PU structure, including cell thickness, are in positive direction.

Since starch constitutes the majority of the biomass material, literature contribution to the starch biopolyol polymerization process is presented. Our research, in which PU foam was synthesized by performing two-step polymerization, brought positive properties to the composite structure in terms of thermal, morphological, degradation and hydrophilicity due to the presence of highly functional components in the composition of potato waste. However, it is a partial disadvantage that the sound transmission rate is slightly higher than commercial thermal insulation materials. This is thought to be due to a partially heterogeneous cell distribution. Therefore, for the reduction of sound speed, must be put in effort.When the agricultural production statistics of the countries and the world are examined, it appears that potato production is high. If the average plant waste is considered to be approximately 5%, a significant amount of biomass resources are available. Our research study has created a useful example for the preparation of composite materials by evaluating biomass. Again, resistance to petroleum products that take many years to degrade, emit harmful gases to the environment and cause global warming will decrease.

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Conflict of Interest

I declare that there is no a conflict of interest with any person, institute, company etc.

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