Journal of Physics: Conference Series

PAPER • OPEN ACCESS

Production of Adhesive from Cassava Starch

To cite this article: A.A. Ayoola *et al* 2019 *J. Phys.: Conf. Ser.* **1378** 032079

Production of Adhesive from Cassava Starch

A.A. Ayoola[1,*], O.S.I. Fayomi[2,3], I.G. Akande[4], O.A. Adeeyo[1], O.R. Obanla[1], O.G. Abatan[1], D.E. Babatunde[1], V.A. Olawepo[1], O.O. Fagbiele[1], V.D. Olomo[1]

[1]Department of Chemical Engineering, Covenant University, Nigeria
[2]Department of Mechanical Engineering, Covenant University, Nigeria
[3]Surface Engineering Research Centre, Tshwane University of Technology, South Africa
[4]Department of Mechanical Engineering, University of Ibadan, Nigeria
[*]Corresponding Author: ayodeji.ayoola@covenantuniversity.edu.ng

Abstract
The research work investigated the production of adhesive from cassava starch. Cassava tubers were processed into starch-based adhesives, using two different gelatinization enhancers (that is HCl and NaOH) which were introduced separately. The adhesives were produced by considering two varied process parameters, namely percentage weight of borax in starch solution (8 – 20%) and reaction temperature (65 – 85^{0}C). Comparative analysis of the adhesive obtained (using HCl and NaOH as gelatinization enhancers) include the determination of its bond strength, viscosity, drying time, pH and density. As the borax weight percent increases up to 14 % and reaction temperature reduces (using NaOH) the drying time increases, while the drying time reduces as both the borax weight percent and temperature reduce (using HCl). The results of the adhesive physical properties fall within the standard range for each of the properties and this implied that the adhesive produced was of high quality.

Key words: Adhesive, cassava, gelatinization, starch, viscosity

1 Introduction

Cassava is a long and tapered root, with a rigid, homogenous flesh encased in a detachable outer skin. It is rough and brown on the outside. It is one of the top sources of food carbohydrates in the tropics. It is a major staple food in the developing world, and provides a basic diet for over half a billion people [1]. It is amongst the most drought-tolerant crops and is capable of growing on marginal soils. The plant can be grown in all soil types, but the root development is better in loose-structured soils, such as light sandy loams and/or loamy sands. It can grow even in infertile soil or soil of pH less than 4.4 (acidic soil), but not in a soil of pH greater than 8 [1–2].

Many products can be derived from cassava such as cassava starch, cassava flour, cassava chips and cassava adhesive [3–5]. Adhesives are substances that are able to make certain materials adhere or stick together without deformation or failure. Adhesives can be categorized as either natural or synthetic. Cassava starch can be processed into adhesive. The use of starch as a raw material in the production of adhesive has some benefits which include renewability, biodegradability, cheapness and stability in price [6–9].
Cassava starch-based adhesive is synthesized by the reaction of cassava starch with gelatinization modifiers, viscosity enhancer (such as borax) and sometimes with other chemicals that act as plasticizers. There are several methods used for the production of cassava starch based adhesives. In using a particular method for cassava starch based adhesive production, a known volume of a particular concentration of a gelatinization modifier (HCl/NaOH) is added to a certain quantity of dried cassava starch and is stirred continuously while heating. The starch/ gelatinization modifier

mixture is then allowed to cool to a lower temperature after which a certain amount of viscosity enhancer (Borax, sodium tetraborate) is added while stirring, until the mixture becomes sticky [6–7].
This research study the effect of the variation of the viscosity enhancer (borax) and reaction time on the quality (properties) of the starch-based adhesive produced, using both HCl and NaOH as gelatinization modifiers.

2 Methods

2.1 Raw materials and chemical reagents

In the course of this study, the raw materials and reagents used include cassava roots (TMS 30001, obtained from International Institute of Tropical Agriculture - IITA Ibadan, Nigeria), distilled water, viscosity enhancer (borax, $Na_2B_4O_7.10H_2O$) and gelatinization modifiers (HCl and NaOH).

2.2 Adhesive production

Minitab 17 software was employed for the experimental design as well as to relate both the main and interactive effects of the processing parameters (concentration of the gelatinization modifiers (NaOH and HCl solution) and the weight percent of borax (viscosity enhancer, $Na_2B_4O_7.10H_2O$) on the properties of the adhesive produced. A face-centered design (with $\alpha = 1$) having a 3 level and a 2 replicate was considered.
Materials, regents and equipment used include cassava tubers from IITA (TMS 30001), Borax ($Na_2B_4O_7.10H_2O$, 98.9%, Qualikems, India), HCl (97%, Riedel-Dietaen, Germany), NaOH (98%, Sigma-Aldrich, UK), NDJ-5S digital rotary viscometer, INSTRON 3345 Universal Testing Machine, USA.
Cassava tubers were peeled, washed and then grated into a pulp. The grated pulps were soaked in water for two days to have the pups ruptured, the mixture was then sieved using a mesh of size 70 µm. The filtrate obtained was allowed to settle in order to obtain coagulated starch slurry. The starch particles obtained was then spread on a clean stainless steel plate and placed in an oven for 20 minutes at 110^0C to obtain dry cassava starch [1–2, 9].
To produce starch-based adhesive, 6g of dry starch obtained was dissolved in 100ml of 0.5M of the gelatinization modifier solution (HCl or NaOH as the case may be) and then stirred continuously at 250rpm. For each of the experimental run (considering Minitab experimental design), heating was done at the specified temperature between 65^0C – 85^0C. And the required concentration of borax/starch solution (within 8 – 20 weight %) was added while stirring until it became sticky. Starch adhesive produced was then allowed to cool for qualitative analysis.

3 Results and Discussion

Table 1 shows the results obtained from the experimental work. Figure 1 shows the interactive effects of the reaction temperature and weight percent of borax in starch on the viscosity of the adhesive produced, using HCl and NaOH solution. Figure 2 shows the result obtained for interactive effects of the reaction temperature and weight percent of borax in starch on the bond strength of the starch adhesive, using HCl and NaOH solution. In Figure 3, the interactive effects of the reaction temperature and weight percent of borax in starch on the drying time of the adhesive produced were shown. Figure 4 shows the interactive effects of the reaction temperature and weight percent of borax in starch on the pH of the adhesive produced. Figure 5 shows the interactive effects of the reaction temperature and weight percent of borax in starch on the density of the adhesive produced.

Table 1: Experimental design and the properties of the adhesive obtained

Wt. % of Borax/Starch	**Rxn Temp. (^{0}C)**	**Viscosity (Pa.s)**	**pH**	**Density (g/cm^3)**	**Bond Strength (kPa)**	**Drying Time (mins)**
14	65	104.40	9.47	1.097	14.60	7.462
8	75	84.61	8.20	1.052	11.60	5.700
14	85	117.47	9.80	1.016	14.91	6.900
20	75	100.26	8.73	1.156	9.50	7.510
14	75	108.63	8.56	1.019	11.83	5.500
14	65	112.09	9.32	1.082	10.81	5.460
8	75	103.38	8.04	1.067	14.51	4.810
14	85	114.56	8.31	1.059	15.03	4.100
20	75	89.36	9.03	1.018	14.70	5.030
14	75	97.60	8.72	1.109	13.83	5.810
20	65	94.18	9.41	1.128	10.04	4.155
20	85	107.44	8.05	1.166	12.58	4.125
20	65	98.17	9.02	1.103	11.24	5.020
14	75	97.64	9.23	1.070	14.29	6.950
8	65	112.47	8.85	1.023	15.67	5.012
8	85	108.36	9.03	1.034	14.18	4.070
8	65	92.46	8.92	1.023	12.60	6.160
8	85	90.06	9.02	1.014	14.17	4.722
14	75	100.53	8.43	1.075	12.91	4.920
20	85	110.03	9.28	1.060	15.31	4.250

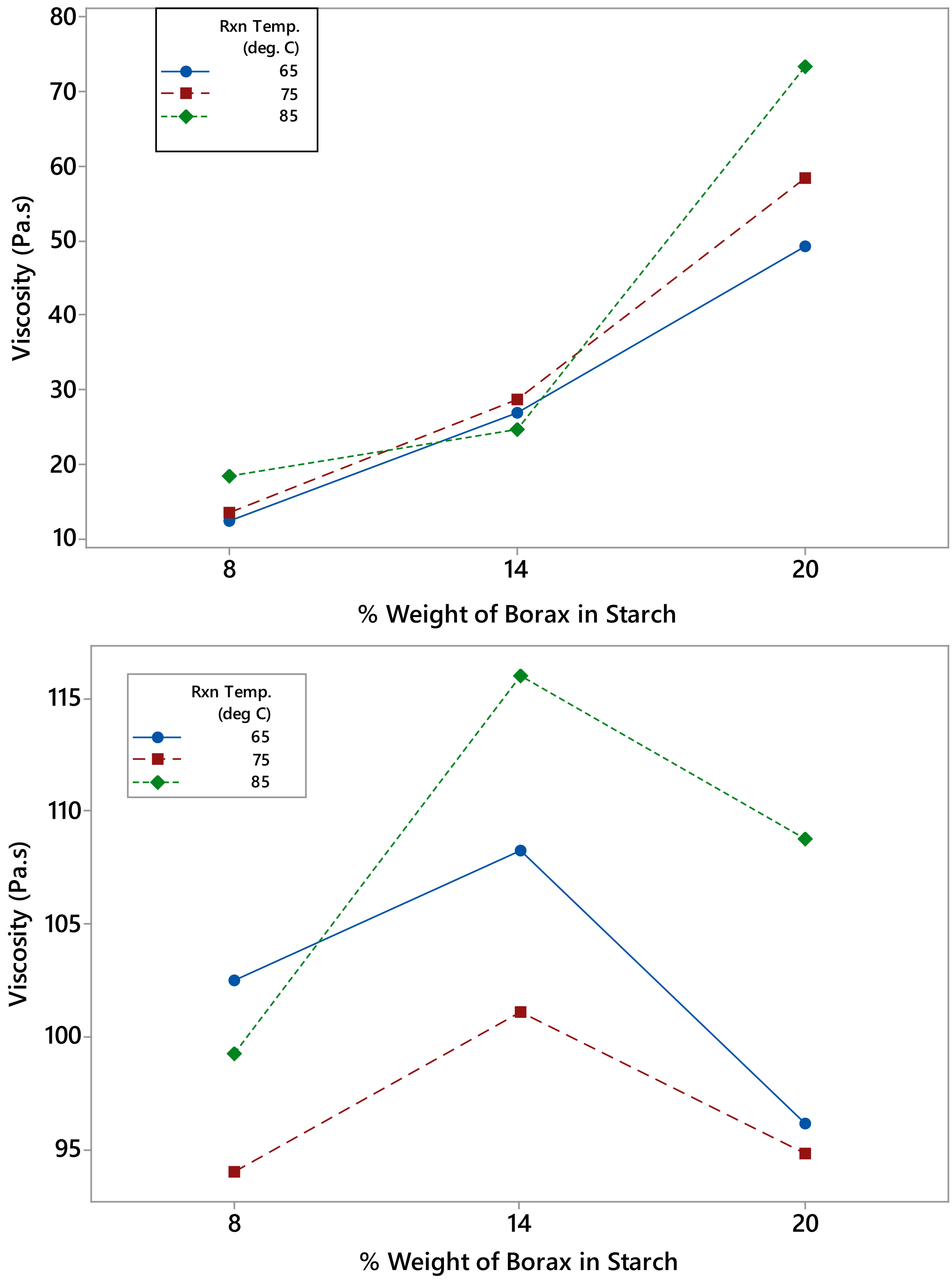

Figure 1: Interactive effects of the reaction temperature and % weight of borax in starch on the viscosity of the adhesive produced, using (a) HCl and (b) NaOH solution.

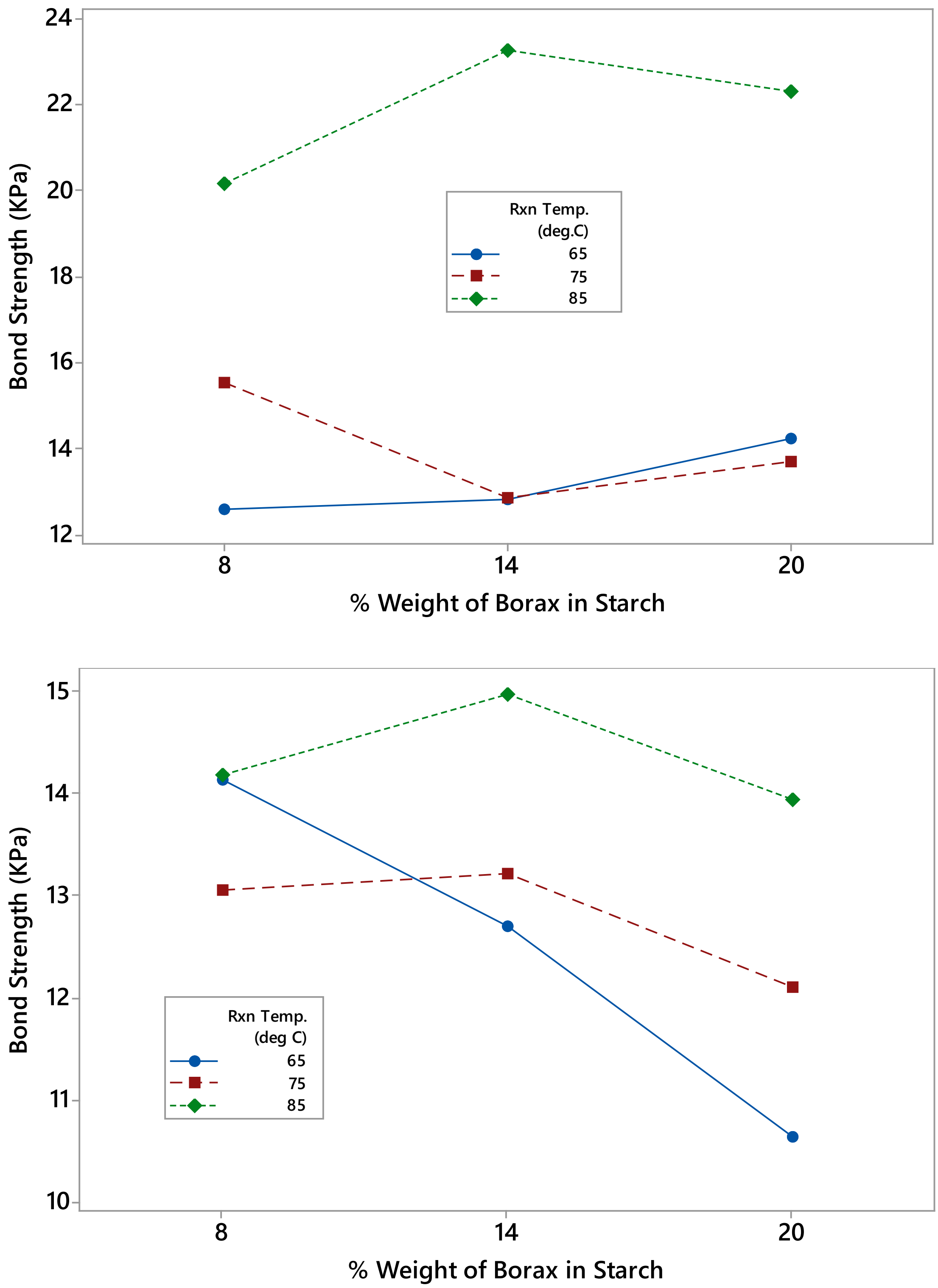

Figure 2: Interactive effects of the reaction temperature and weight percent of borax in starch on the bond strength of the starch adhesive, using (a) HCl and (b) NaOH solution

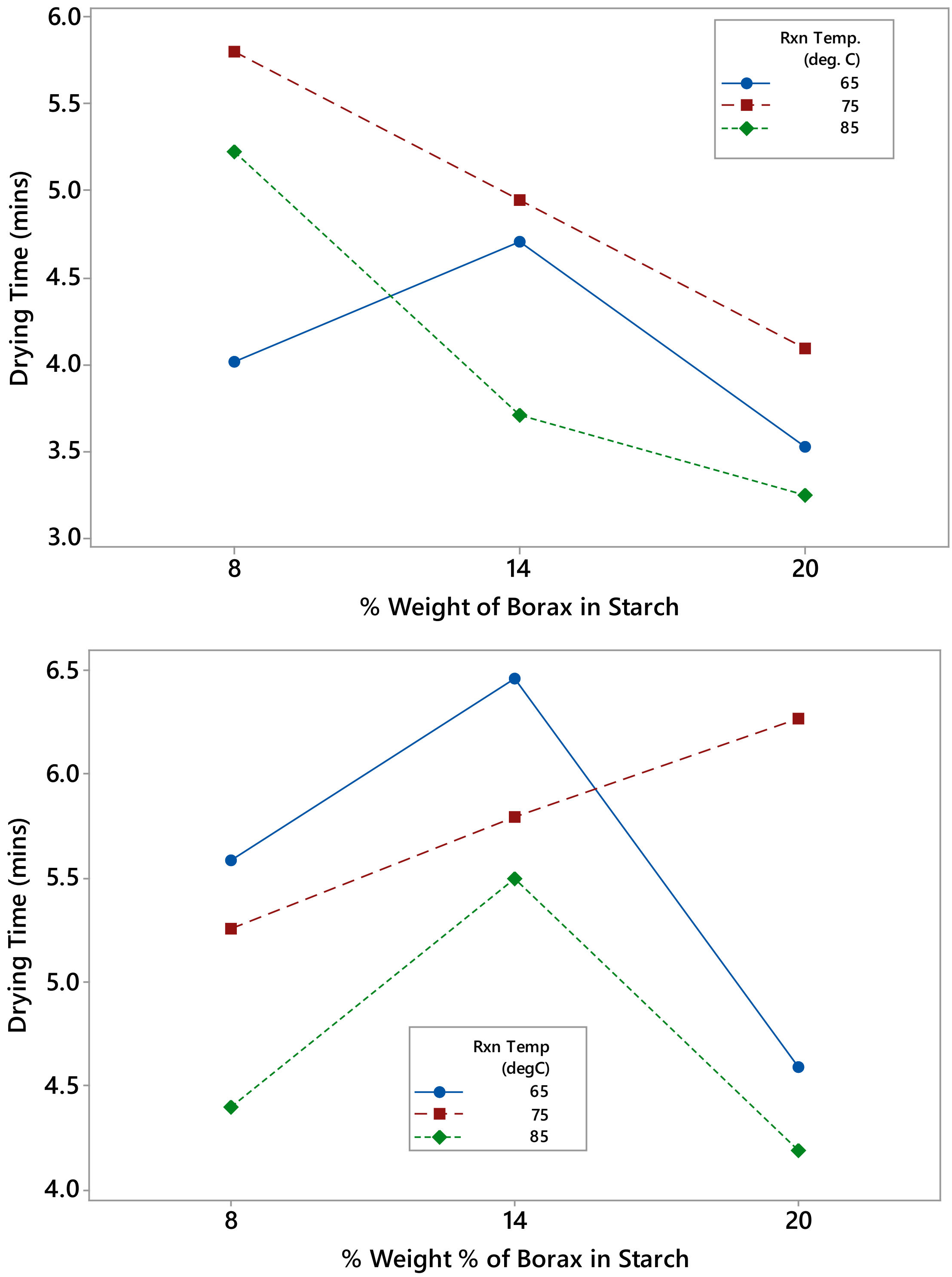

Figure 3: Interactive effects of the reaction temperature and weight percent of borax in starch on the drying time of the starch adhesive, using (a) HCl and (b) NaOH solution

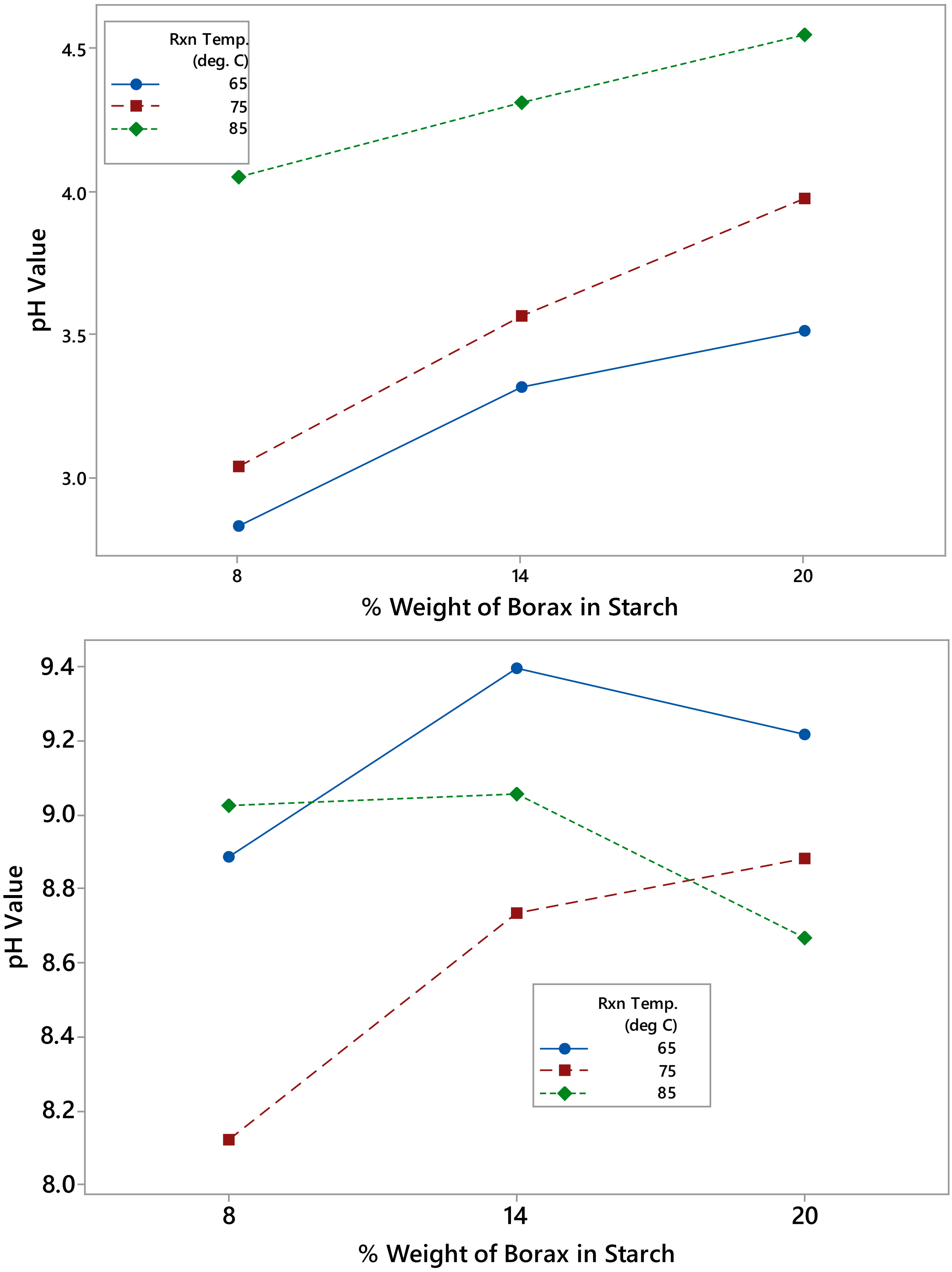

Figure 4: Interactive effects of the reaction temperature and weight percent of borax in starch on the pH of the starch adhesive, using (a) HCl and (b) NaOH solution

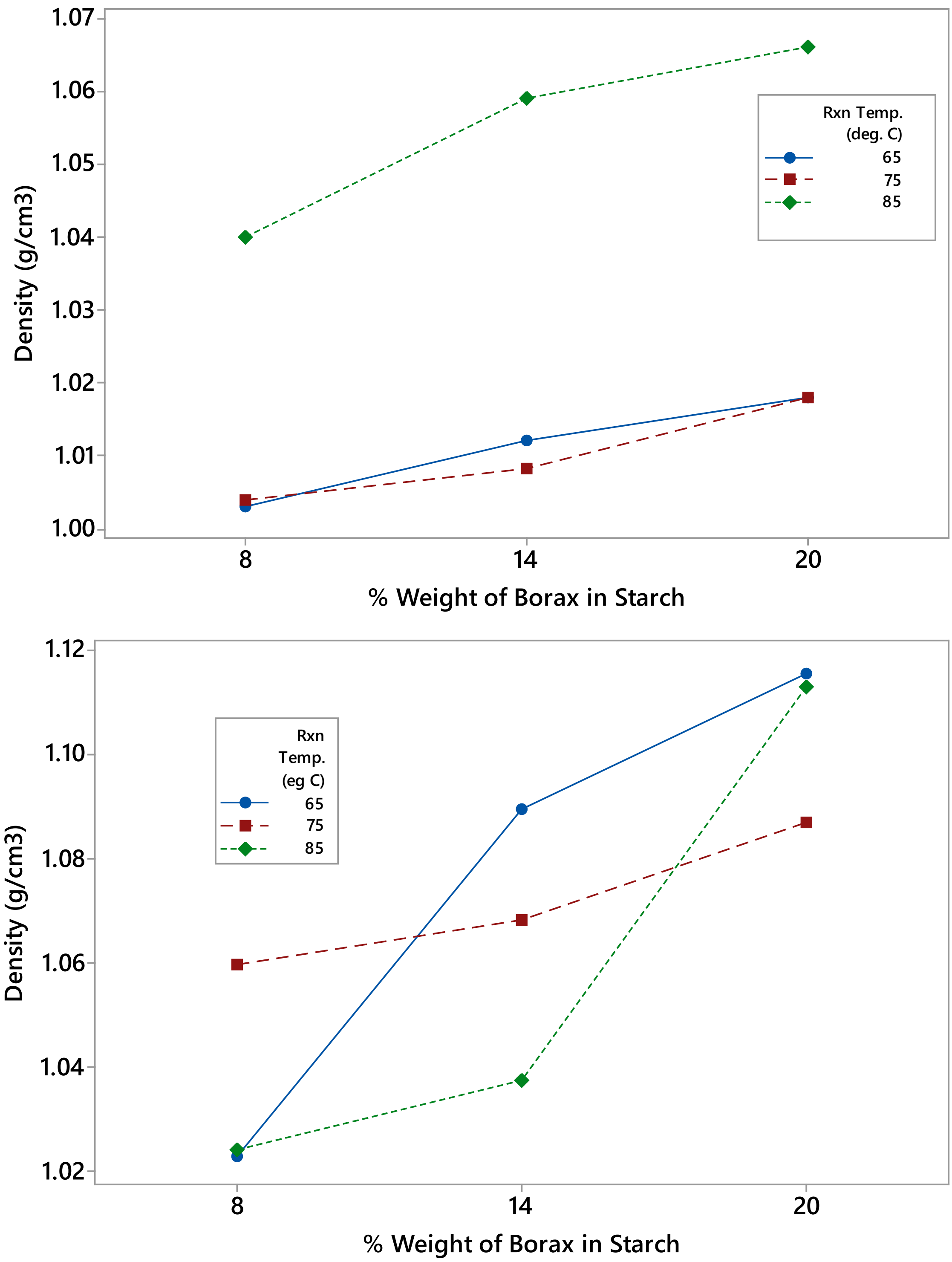

Figure 5: Interactive effects of the reaction temperature and weight percent of borax in starch on the density of the starch adhesive, using (a) HCl and (b) NaOH solution

From the results obtained, the following points can be made:

1. Increase in weight percent of borax and temperature (for range considered), increase the viscosity of the adhesive produced (for both HCl and NaOH gelatinisers).
2. Bond strength of the adhesive reduces as the reaction temperature reduces and weight of borax increases for the two gelatiniser considered.
3. As the borax weight % increases up to 14 % and reaction temperature reduces (using NaOH) the drying time increases while the drying time reduces as both the borax weight percent and temperature reduce (using HCl).
4. Increase in both the weight percent of borax and temperature (for range considered), increase the pH of the adhesive produced (for HCl) and increase in weight percent of borax and decrease in temperature (for range considered), increase the pH of the adhesive produced (for NaOH gelatiniser).
5. Increase in both the weight percent of borax and temperature (for range considered), increase the density of the adhesive produced (for HCl) and increase in weight percent of borax and decrease in temperature (for range considered), increase the density of the adhesive produced (for NaOH gelatiniser).

4.0 Conclusion

This experimental study revealed that the processing of cassava tubers can produce starch-based high-quality adhesive, using two different gelatinization enhancers (HCl and NaOH).

Acknowledgement

Appreciation goes to Covenant University Centre for Research Innovation and Discovery (CUCRID) Ota, Nigeria for the financial provision towards the publication of this research work.

References

[1] Gunorubon, A.J. (2012). Production of cassava starch-based adhesive. Research Journal of Engineering and Applied Sciences, 1(4), 219–214.
[2] Ojewumi, M.E., Adeeyo, O.A., Akingbade, O.M., Babatunde, D.E., Ayoola, A.A., Awolu, O.O., Ojewumi, E.O., & Omodara, O.J. (2018). Evaluation of glucose syrup produced from cassava hydrolyzed with malted grains (rice, sorghum & maize). International Journal of Pharmaceutical Sciences and Research, 9(8), 1000–1111.
[3] Ayoola A.A, Sanni S.E, Ojo T., Omonigbeyin O., Ajayi A.A, Olawole O.C., Ajayi O.M. (2018). Production of A novel bio-polymer for enhanced oil recovery and modelling the polymer viscosity using Artificial Neural Network (ANN), International journal of Mechanical Engineering & Technology, 9(12), 563–574.
[4] Ayoola, A.A., Adeniyi, D.O., Sanni, S.E., Osakwe, K.I., Jato, J.D. (2018b). Investigating production parameters and impacts of potential emissions from soybean biodiesel stored under different conditions, Environmental Engineering Research, 23(1), 54–61.
[5] Obanla, O.R., Ojewumi, M.E., Ayoola, A.A., Omodara, O.J., Falope, F.Y., Gbadamosi, O.H. (2019). Comparative and experimental study on the properties and potency of synthesized organic and mineral sunscreen moisturizer, International Journal of Mechanical Engineering and Technology, 10(01), 612–625.
[6] Ayoola A.A., Adeeyo O.A., Efeovbokhan V.E, Ajileye, O. (2012). A Comparative study on

glucose production from *Sorghum Bicolor* and *Manihot Esculenta* Species in Nigeria. International Journal of Science and Technology, 2(6), 353 – 357.
[7] Ayoola, A.A., Hymore, K.F., Omonhinmin, C.A. (2017). Optimization of biodiesel production from selected waste oils using response surface methodolody. Biotechnology, 16(1), 1–9.
[8] Fayomi, O.S.I., Popoola, A.P.I., Ige, O.O., Ayoola A.A. (2017). Study of particle incorporation and performance characteristic of aluminium silicate-zirconia embedded on zinc coatings for corrosion and wear performance. *Asian Journal of Chemistry*, 29(12), 2575–2581.
[9] Opara, I.J., Ossi, C.D., OkoUdu, C.O. (2017). Formulation of cassava starch-based adhesive. International Journal of Advanced Research, 5(7), 26–33