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MODELING OILFIELD DEMULSIFICATION PROPERTIES OF *Annona Muricata* SEED OIL DERIVED EXTRACTS

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ABSTRACT

In this study, oilfield demulsification properties of soursop seed oil extracts were investigated. The study utilized previously obtained data from experimental study of the demulsification properties of the tropical soursop fruit containing data points on various variables, including acid number, density, saponification value, specific density, hydrpohylic-lipophylic balance (HLB), dielectric constant, pH and viscosity. The modeling process involved an initial

Introduction

One of the significant problems facing petroleum industries is the resolution of water in oil emulsions (Zhai *et al.*, 2020). A regular oilfield emulsion is a dispersion of water droplets in oil. Emulsions are generally not desirable in the petroleum industry for a number of reasons. The presence of water-in-oil increases operation costs in the form of demulsification expenses and increased pumping or heating costs (Raynel *et al.*, 2021). Oilfield emulsions, if not tackled, can lead to numerous production issues like corrosion damage and distortion of normal downstream operations in refineries, while reducing the quality index of crude oil samples. To avoid formation of unwanted emulsions, the acceptable water content of crude oil samples is usually less than 0.5% (Abdulredha *et al.*, 2022). Demulsification is the breakdown of emulsion into its incompatible individual phases, particularly water and oil (Saad *et al.*, 2020). This is a very important process in petroleum industries, where emulsions occur almost always either naturally or consciously made by man. Several methods currently available for demulsification of

effort of asertaining the correlations of the variables with the dependent variables. This was done to be able to determine which independent variables have enough correlation to be included in the final equations for both dielectric constant and hydrpohylic-lipophylic balance (HLB). From the correlations, it was found that a quadratic curve gave the best fit for the relationship between the dependent and independent variables. From the final equations, it was found that dielectric constant was a function of saponificaton value, hydrpohylic-lipophylic balance and viscosity; while hydrpohylic-lipophylic balance was found to be dependent on dielectric constant, saponification value and viscosity. Considering the nature of the developed models, it can be seen that although both density and specific density were part of the model building process, their coefficients in the final models were found to be zero.

Keywords: soursop seed oil, oilfield chemicals, demulsifier, green chemistry, mathematical model

crude oil include chemical, electrical, thermal, mechanical methods or their combinations. Chemical demulsification is one of the most widely applied in the petroleum industries because of the ease of application of the chemicals, low cost as well as minimal heat and settling time requirements (Efeovbokha *et al,* 2017). The mechanism of demulsification involves the surface-active compound moves to an oil-water interface and breaks the attractive bonds, which cause the water droplets to coalesce (Admawi & Mohammed, 2023).

Chemical demulsification involves the use of chemicals known as demulsifiers to reduce the stability of the emulsions and assist in its coalescence and eventual separation (Raya *et al*., 2020). Crude oils vary considerably in emulsifying tendencies (Duru *et al*., 2016). Some form very stable emulsions that are difficult to separate. Others do not emulsify or form loose emulsions that separate quickly. Hence the demulsifiers need to be properly formulated in order to meet the requirement needed in breaking the emulsion with little agitation (Adeyanju & Oyekunle, 2018). Demulsifier formulations involve a combination of two to four different but compatible chemicals, in carrier solvent(s) such as isopropanol, methanol, xylene or diesel.

In the oil and gas industry, there is a substantial need to further investigate and optimize the effect of emulsions in crude oil on the flow rate and pressure of fluid flow in pipeline using chemical (demulsifiers) injection (Saad *et al*., 2020). A large number of tests have been performed in the field by injecting various dosages of demulsifier and the results of these tests show varying percentages of increase in flow-rate and pressure. This scenario requires modeling of existing demulsification process to ascertain optimal operating conditions. In this study, the demulsification properties of green seed oil extracts derived from the tropical soursop fruit will be modeled.

Materials and Methods

Previously obtained data from experimental study of the demulsification properties of the tropical soursop fruit were utilized for this study. The experimental data contained various data points on various variables, including acid number, density, saponification value, specific density, hydrpohylic-lipophylic balance (HLB), dielectric constant, pH and viscosity. Here, the dependent variables were chosen to be dielectric constant and hydrpohylic-lipophylic balance (HLB).

The modeling process involved an initial effort of asertaining the correlations of the variables with the dependent variables (Ojinnaka *et al.*, 2016). This was done to be able to determine which independent variables have enough correlation to be included in the final equations for both dielectric constant and hydrpohylic-lipophylic balance (HLB).

The final equations were obtained as follows:

$$D = 0.05194X_1 + 47.895X_2 - 2.76232X_3 - 908.443 \quad (1)$$

Where D = dielectric constant (-),X_1 = saponification value (mgKOH/gOil), X_2 =HLB (1-S/A) and X_3 = viscosity (mPaS)

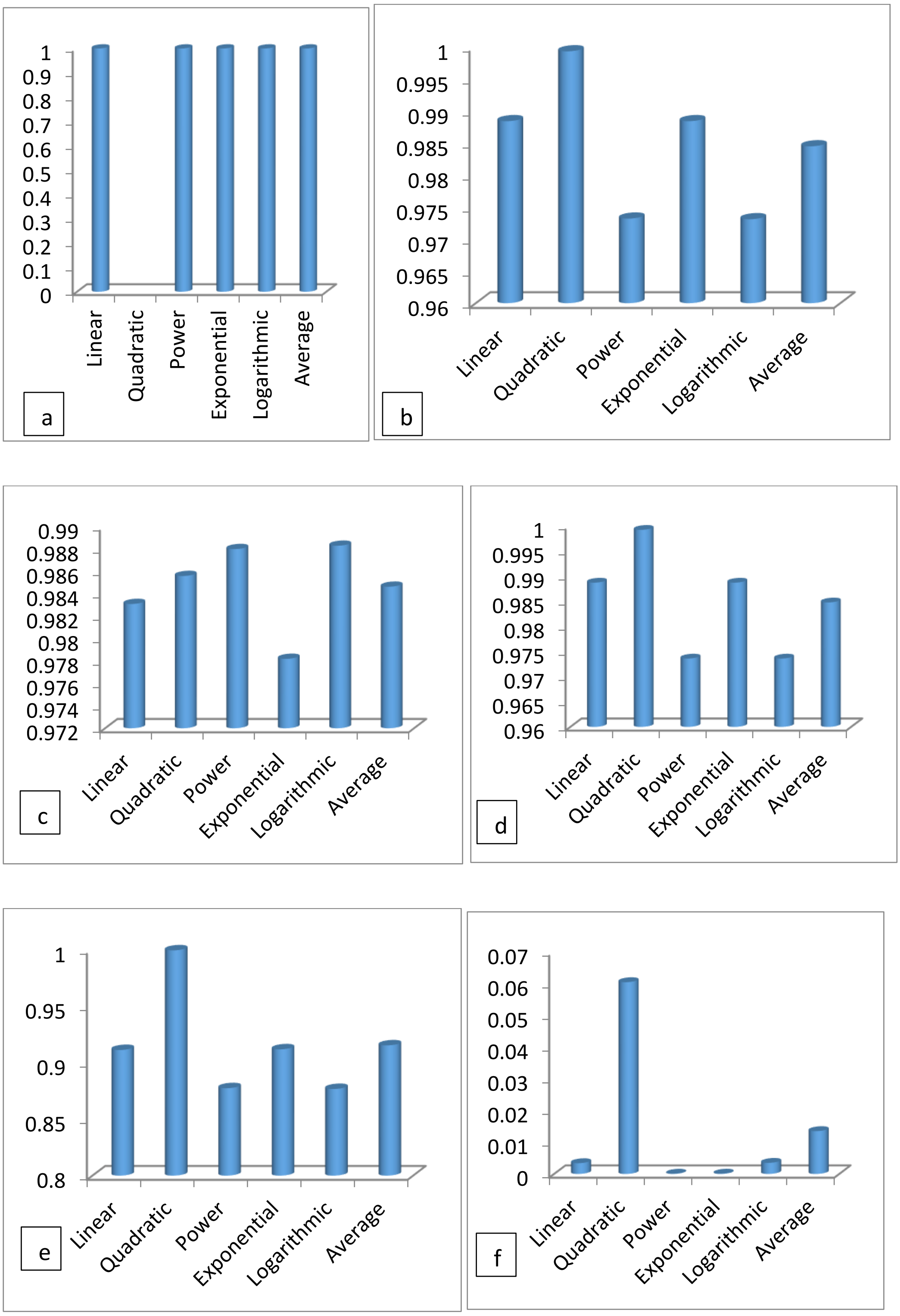
$$H = 0.020879X_1 + 0.05767X_2 - 0.00108X_3 + 18.967 \quad (2)$$

Where H = hydrpohylic-lipophylic balance (1-S/A), X_1 = dielectric constant (-), X_2 = viscosity (mPaS) and X_3 = saponification value (mgKOH/gOil)

Considering the nature of the developed models, it can be seen that although both density and specific density were part of the model building process, their coefficients in the final models were found to be zero. Hence, it can further be asserted that both hydrophylic-lipophylic balance and dielectric constant are not dependent on either density or specific density. Therefore, any previously reported associations between the variables from the curve fitting process can best be described as superficial.

Results and Discussion

Figure 1 shows the coefficients of determination (R^2) for various mathematical models between dielectric constant and other parameters for demulsification. Again, it can be deduced that quadratic model consistently gave the highest coefficint of determination among the models apart from acid number in which all reported coefficients had values of 1. The coefficient of determination between dielectric constant and acid number can consequently be described as undefined, given the fact that no quadratic curve could be fit to their relationship. For the other parameters, their average coefficients were found to be all above the threshold value of 0.800, except for pH, which gave a very low average coefficient value of 0.013.



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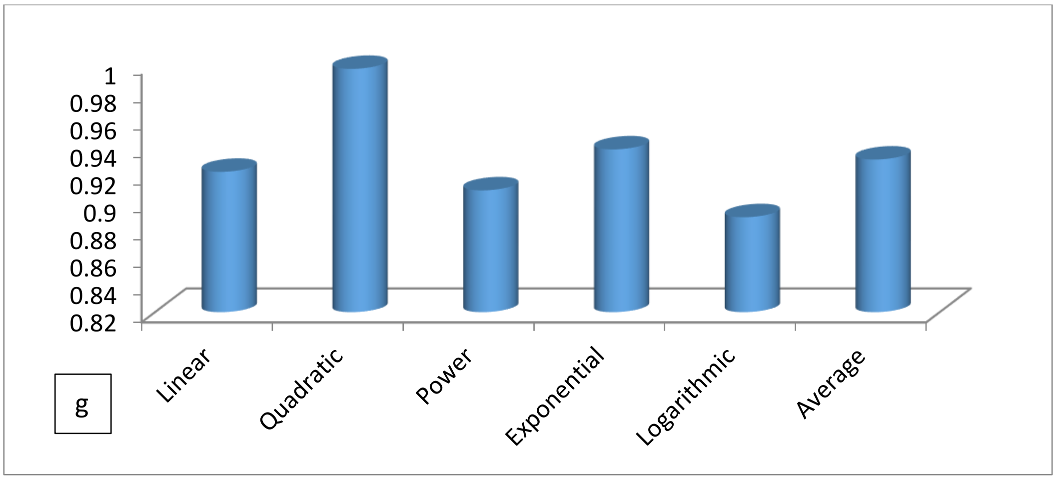
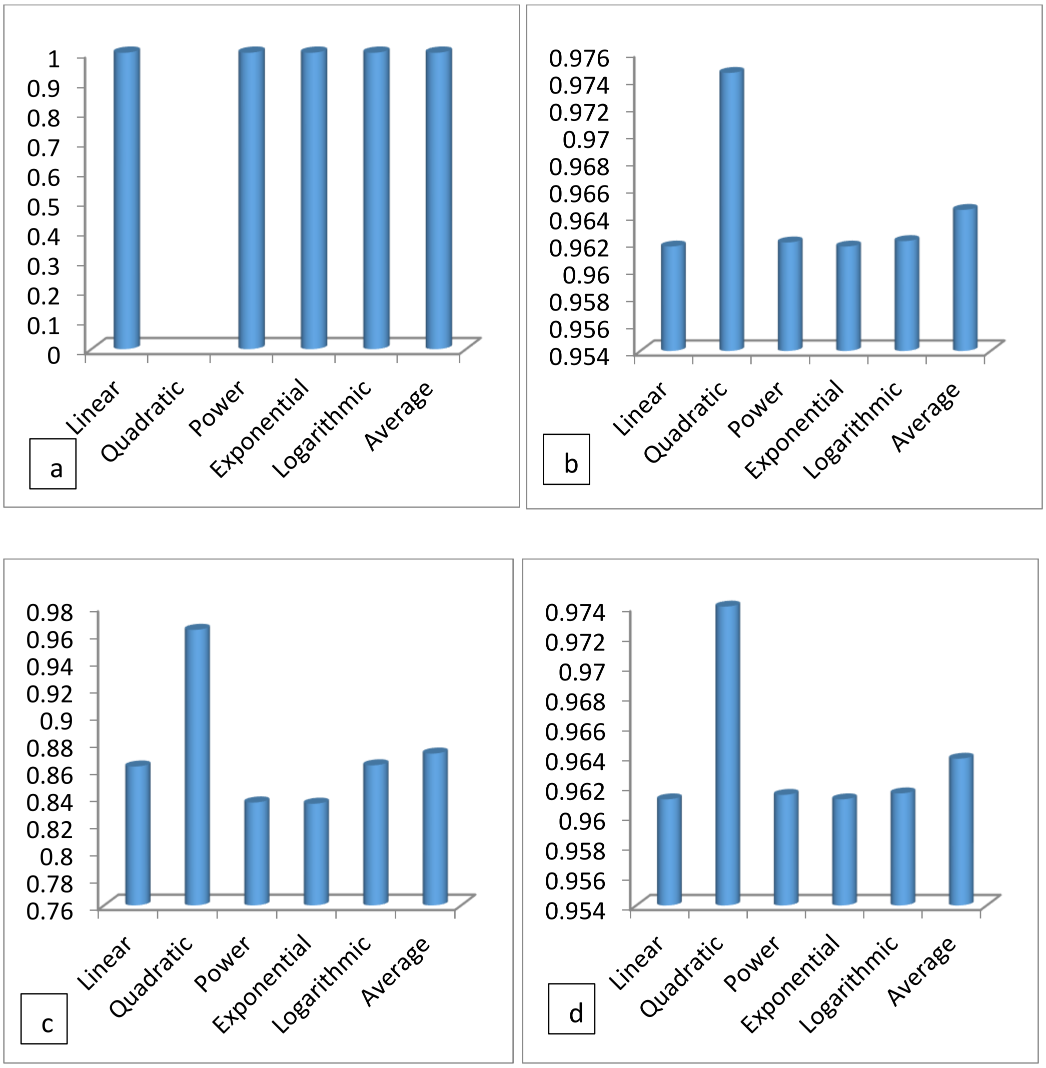


Figure 1 Demulsification coefficients of determination (R^2) for various mathematical models between dielectric constant and (a) acid number (b) density (c) saponification (d) specific gravity (e) HLB (f) pH (g) viscosity



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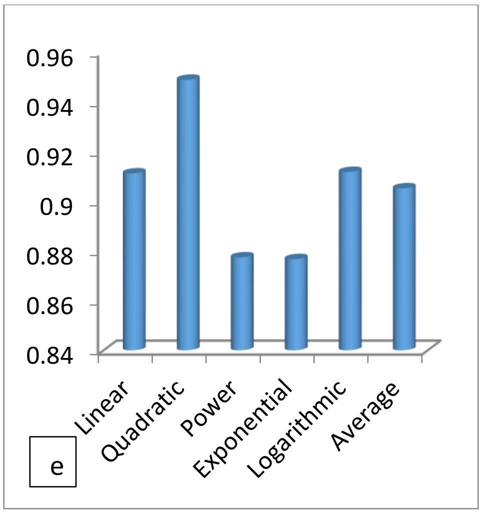

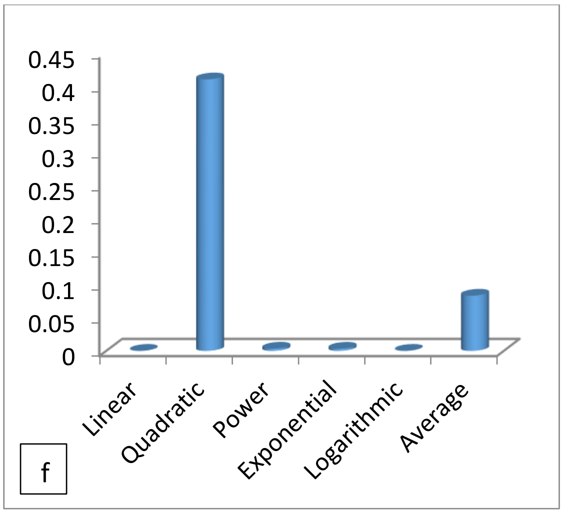

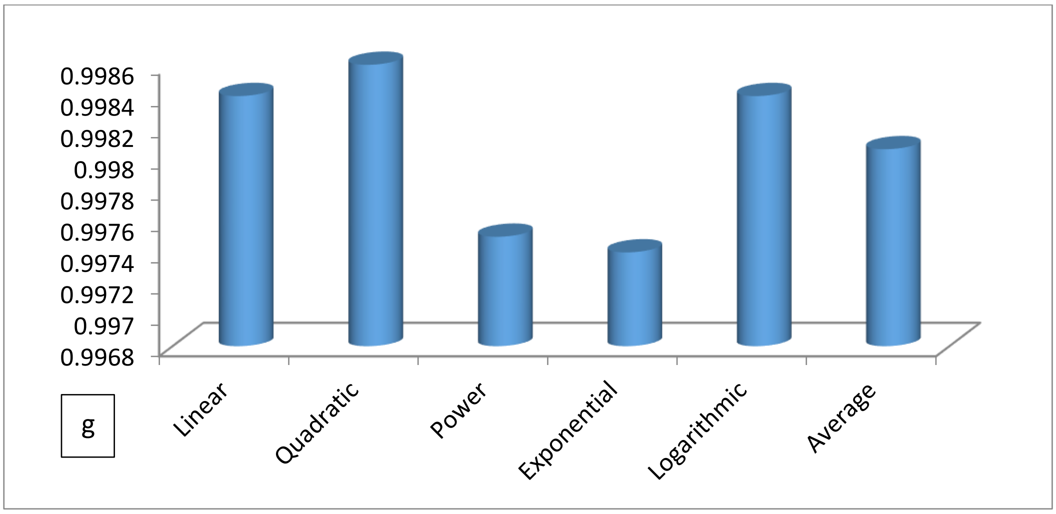

Figure 2 Demulsification coefficients of determination (R^2) for various mathematical models between HLB and (a) acid number (b) density (c) saponification (d) specific gravity (e) dielectric constant (f) pH (g) viscosity

This suggests a reasonably high correlation between dielectric constant and other parameters like density, saponification, specific gravity, HLB, and viscosity for demulsification. However, for demulsification, there exists no correlation between dielectric constant and pH. Subsequently, acid number and pH parameters were not included in the modelling process.

Figure 2 shows the coefficients of determination (R^2) for various mathematical models between HLB and other parameters for demulsification. Again, it can be deduced that quadratic model consistently gave the highest coefficint of determination among the models apart from acid number in which all reported coefficients had values of 1. The coefficient of determination between HLB and acid number can consequently be described as undefined, given the fact that no quadratic curve could be fit to their relationship. For the other parameters, their average coefficients were found to be all above the threshold value of 0.800, except for pH, which gave a very low average coefficient value of 0.013.

This suggests a reasonably high correlation between HLB and other parameters like density, saponification, specific gravity, dielectric constant, and viscosity for demulsification. However, for demulsification, there exists no correlation between HLB and pH. Subsequently, acid number and pH parameters were equally not included in the modelling process.

The developed models were later validated using experimental data as captured in Figures 3 and 4 for dielectric constant and hydrophylic-lipophylic balance respectively. From the charts, it can be seen that the developed models clearly simulated the experimental data very well, with all the data points found on the linear curve of best fit. This underscores the accuracy of the regressional models developed for both dielectric constant and hydrophylic-lipophylic balance of the new green demulsifiers.

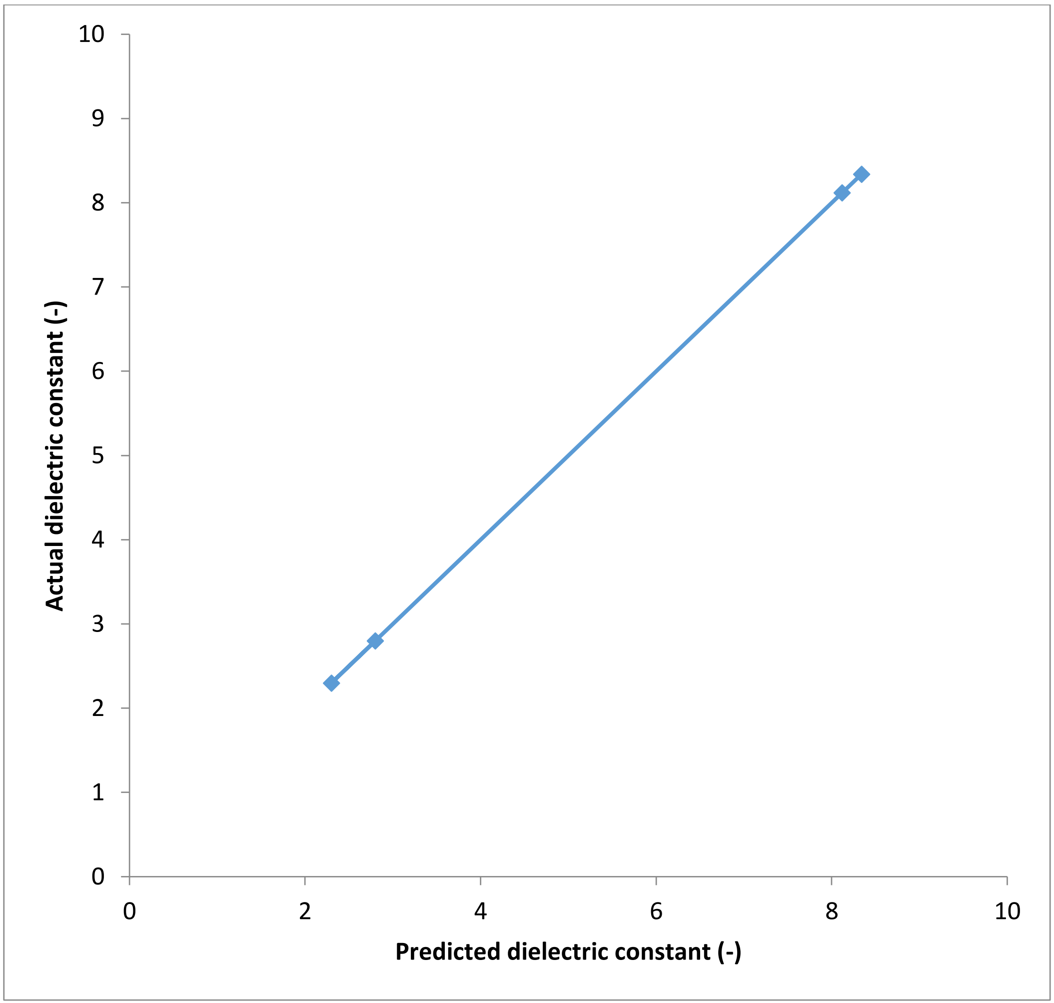

Figure 3 Validation of developed dielectric constant model

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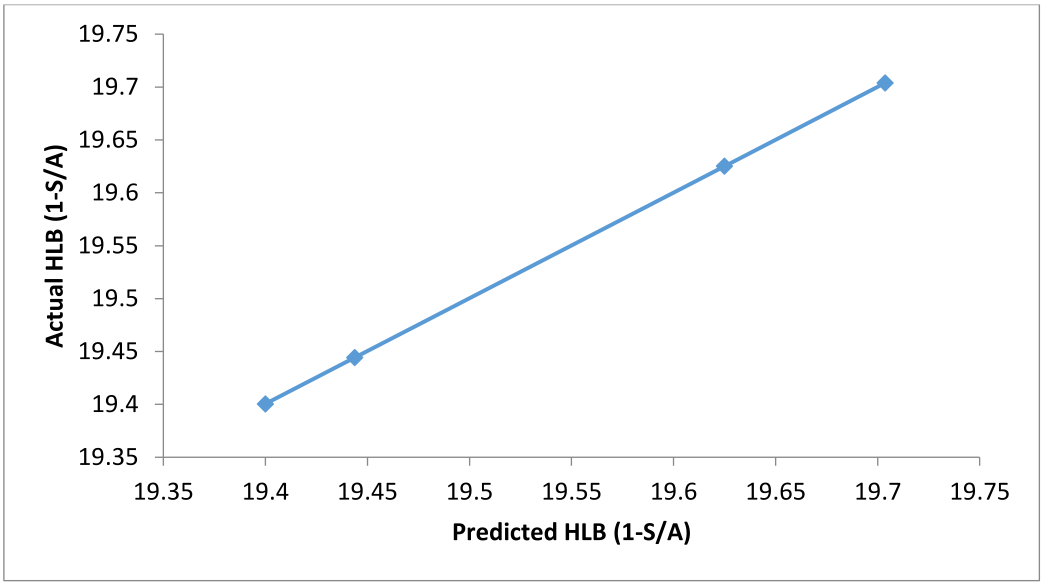

Figure 4 Validation of developed hydrophylic-lipophylic balance model

Conclusion

The demulsification properties of soursop seed oil extracts were modeled in this study. The modeling process involved an initial effort of asertaining the correlations of the variables with the dependent variables. This was done to be able to determine which independent variables have enough correlation to be included in the final equations for both dielectric constant and hydrpophylic-lipophylic balance (HLB). From the correlations, it was found that aquadratic curve gave the best fit for the relationship between the dependent and independent variables.

From the final equations, it was found that dielectric constant was a function of saponificaton value, hydrpohylic-lipophylic balance and viscosity; while hydrpohylic-lipophylic balance was found to be dependent on dielectric constant, saponification value and viscosity. However, it was found that both density and specific density do not affect either the demulsifier dielectric constant or hydrophylic-lipophylic balance. Therefore, any previously reported associations between the variables from the curve fitting process can best be described as superficial.

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Appendix

Table 1 Properties of crude oil samples used for the demulsification study

Variable	16AU	219	343	445	MIX BLEND
Acid Number	9.34	12.3	9.21	9.13	9.42
API	22.3	7.5	22.4	17.4	17.8
Density	0.9034	0.9957	0.9029	0.9261	0.9938
Saponification	327.12	376.22	320.44	351.28	348.21
Specific Gravity	0.92	1.018	0.92	0.96	1.016
HLB	19.42896	19.346	19.425	19.48	194589
Dielectric constant	2.3	2.53	2.46	2.48	2.49
PH	6.7	6.6	6.6	6.4	6.2
Viscosity	22.3	21.9	21.6	34.4	33.2

Table 2 Properties of soursop seed oil extract derived demulsifiers

Variable	Demulsifier A		Demulsifier B	
Acid Number	6.732	5. 8905	2.5245	2.244
Density	0.8814	0.8821	0.8925	0.8932
Saponification	224.4	211.7775	134.64	151.47
Specific Gravity	0.9012	0.9019	0.9126	0.9133

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Variable	Demulsifier A		Demulsifier B	
HLB	19.4	19.4437	19.625	19.7037
Dielectric constant	8.34	8.12	2.3	2.8
PH	5.7	8.6	7.2	6.7
Viscosity	8.7	9.3	13.1	14.6

Table 3 Demulsification coefficients of determination (R^2) for various mathematical models between dielectric constant and other parameters

Parameter	Coefficient of Determination					Average
	Linear	Quadratic	Power	Exponential	Logarithmic	
Acid Number	1	-	1	1	1	1
Density	0.9884	0.9993	0.9732	0.9884	0.9731	0.98448
Saponification	0.9831	0.9856	0.988	0.9782	0.9883	0.98464
Specific Gravity	0.9887	0.9992	0.9736	0.9887	0.9736	0.98476
HLB	0.9112	0.9994	0.8774	0.9118	0.8767	0.9153
pH	0.0034	0.0605	0.00008	0.0001	0.0035	0.013516
Viscosity	0.922	0.9968	0.9085	0.9383	0.889	0.93092

Table 4 Demulsification coefficients of determination (R^2) for various mathematical models between hydrophilic-lipophilic balance (HLB) and other parameters

Parameter	Coefficient of Determination					Average
	Linear	Quadratic	Power	Exponential	Logarithmic	
Acid Number	1	-	1	1	1	1
Density	0.9617	0.9745	0.962	0.9617	0.9621	0.9644
Saponification	0.8623	0.963	0.8358	0.8349	0.8632	0.87184
Specific Gravity	0.9611	0.974	0.9614	0.9611	0.9615	0.96382
Dielectric constant	0.9112	0.9489	0.8774	0.8767	0.9118	0.9052
pH	0.00008	0.4102	0.0033	0.0032	0.00007	0.08337
Viscosity	0.9984	0.9986	0.9975	0.9974	0.9984	0.99806