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OPINION DISCRIMINATION ANALYSIS OF FACTORS AFFECTING THE MANUFACTURING PROCESS OF RUBBER SEED OIL BASED ALKYD RESIN

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ABSTRACT

Over the years the unpredictability in production output, low quality, wastes, and downtimes appears to be a serious production problem which manufacturers of synthetic alkyd resin products are facing. This invariably affects manufacturers' economic performance and the nation economic growth which are often caused by differences in process temperatures and length of the resin. There is a strong incentive in controlling the end of the batch product property values in order to minimize the variability in product quality. This study seeks to investigate the relationship among variables capable of affecting the production process output of rubber seed oil based alkyd resin using opinion discrimination analysis. A random survey of relevant literature was conducted to gather relevant information required in the manufacturing process of rubber seed oil based alkyd resin for use in surface coating application. Our result showed that there is a strong relationship between temperature, catalyst, absence of catalyst, length of resin, acidic content, water resistance which can be manipulated to appreciably reduce product degradation and control process variability. Moreover, the study has revealed that opinion discrimination analysis modelling tool can be used to determine the production process approach for alkyd resin. The study has proficiently demonstrated that opinion discrimination analytical modelling tool is very effective.

KEYWORDS: Opinion discrimination analysis (ODA), Discriminative power (DP), rubber seed oil, alkyd resin, Likert scale model.

1.0 INTRODUCTION

Natural rubber plant, otherwise known as *Hevea brasilensis* in botanical field is a high utility resource base. At present, there are widespread abundance of rubber in Nigerian states of Edo, Oyo and Ondo that can source adequate amounts of latex, cake meal and rubber seed oil, which is potential base oil for the manufacture of alkyd resins. These rubber derivatives find their uses in the manufacture of leather, putty, soaps/detergents, cosmetics, drugs and alkyd resins (Menkiti and Onukwuli, 2011).

The term "alkyd" originally comes from "al", referring to alcohol, and "kyd", referring to acid. Nowadays, the term alkyd refers to polyesters modified with fatty acids. Alkyds are prepared via condensation polymerization of three types of monomers: polyalcohols, polybasic acids, and fatty acids or triglyceride oils to obtain fatty-acid containing polyesters (Aigbodion and Okieimen, 1996). According to Aigbodion (1991) rubber seed oil is unique because of its relative abundance, level of unsaturation and possession of similar properties with linseed oil, which is traditionally employed in the manufacture of Alkyd Resins. In addition, the author noted that due to non-use of RSO for edible purposes, it stands out as a veritable substitute for the linseed oil which is currently being imported into the country at a great cost. Doubts have been expressed about the sustained successful use of RSO for the large scale production of alkyd resin. Such doubts are attributed to fears that low percentage yield may result from the sourcing of oil from the rubber seed (Menkiti and Onukwuli, 2011). Many researches had been conducted to verify the sustainability of RSO in the manufacture of alkyd resin. Such research includes Ogunniyi and Njikang (1998), Hlaing and Oo (2008), Muzong et al (2015), Adeleke et al (2018). Similar studies are: Nwankwo et al (1986), Ikhuoria and Okieimen (2005), Hasnat (2017).

Improving product quality is the most preoccupation of industrial managers and engineers, due to the stringent industrial specification that today's alkyd resin must meet, the need for fine tuning the factors that causes variability is more acute than ever. Controlling the end of the batch product property values so as to minimize the variability in product quality in order to reduce wastes in production output, low quality outputs, poor equipment designs and production process equipment downtimes among others appear to be some of the major

problems which manufacturers of rubber seed oil based alkyd resin and biodiesel product usually encounter in the cause of production (Igboanugo and Nwobi-Okoye, 2012).

The cause of low quality output and waste observed by Iyayi et al (2008) is traceable to the nature of the finished product or lack of proper maintenance of the process line for the production process. The authors noted that wastes and low quality product are serious production problems which manufacturers of product are facing and it invariably affect manufacturers' economic performance and the nation economic growth in general, it is essential therefore that the causes be investigated with a view to eliminating them.

The opinion discrimination analysis or opinion discrimination analytical (ODA) modelling approach adopted in this study is predictive and innovative by nature in the sense that it foresees the imminence of process capability deterioration. Igboanugo and Nwobi-Okoye (2012) has clearly confirmed the versatility and applicability of opinion discrimination analytical modelling approach and its effectiveness in dealing with the problem of process variability and degraded output. Amiebenomo et al (2013) also confirmed the opinion discrimination analytical modelling approach relevance in enhancing product quality, reduction of wastes, equipment and production system's management as well as its effectiveness in dealing with the problem of identifying the key faults associated with diesel generator in service. The balance of literature on production system appears to offer little on opinion discrimination analytical modelling approach applications that is why the current research effort is geared towards breaching this perceived gap in knowledge. The aim of this study is to demonstrate the feasibility of applying opinion discrimination analysis (ODA) to analyze factors affecting the manufacturing process of rubber seed oil based alkyd resin. This effort is believed to help deals with the problem capable of causing a dysfunction in the manufacturing process of rubber seed oil based alkyd resin for use in surface coating manufacture.

2.0 MATERIALS AND METHODS

2.1 Research Design

The research design adopted involves the application of survey method to collect appropriate information needed to build related data matrix. To achieve this objective, relevant literature was surveyed to identify gamut of variables that influence the manufacturing process of rubber seed oil based alkyd resin. Twenty nine (29) variables (scale items) identified from the wide literature survey conducted were used to craft questionnaire administered to

knowledgeable respondents. Furthermore, Rensis Likert's 5-point attitudinal scale (*5-Strongly Agreed, 4-Agreed, 3-Undecided, 2-Disagree, 1-Strongly disagree*) was used in dimensioning the respondents' responses, which were captured in a 100×29 data matrix that was subsequently analysed with opinion discrimination analytical tool to obtain the discriminative powers (DP). Accordingly, the discriminative power index (DP) was constructed by re-arranging the data matrix into four quartiles. The first and last quartiles were selected for computation of average weights. The difference between average weights of the first quarter and fourth quarter gives the DP values. The DP values were plotted as bar chart and interpretations rendered. The DP-values are segmented as follows:

- **Lower bandwidth:** $2.4 < DP \leq 3.0$

In this regime, the respondents are in total agreement on the issue considered. In other words there is consensuality.

- **Middle bandwidth:** $3.1 < DP \leq 4.0$

In this group, the respondents are fairly in agreement on the subject matter.

- **Upper bandwidth:** $DP > 4.0$

In this category, the respondents are weakly in agreement with what was put forth.

2.2. Models Employed

The Two distinctive models employed in this research work are: (i) Rensis Likert's 5-point attitudinal scale model and (ii) Discriminative Power Index.

2.3 Theoretical Framework

Consider a data matrix R constructed with a four point Rensis Likert's attitudinal scale. If "ij 0 l+ is the element of i^{th} row and j^{th} column, where a_{ij} is the response of the i^{th} respondent to j^{th} question crafted with the scale item and entries in R are recorded in descending order of a_{ij}, it follows that:

$$a_{ij} \in Ra_{(i+1)j} \leq a_{ij} \forall_j$$

Establish 4 quartiles of R, namely: Q_1, Q_2, Q_3 and Q_4

where:

$Q_i \subset R$, I = 1, 2, ...4

Discard Q_2 and Q_3 and use Q_1 and Q_4 to calculate discrimination power (DP).

DP calculations: Consider Table 1 and 2 below

Table 1: Frequency table for Q1.

S/N	Rating (r)	Frequency (f)	(rf)
1	4	0	0
2	3	0	0
3	2	0	0
4	1	3	3

Table 2: Frequency table for Q4.

S/N	Rating (r)	Frequency (f)	(rf)
1	4	3	3
2	3	0	0
3	2	0	0
4	1	0	0

let the weighted average WA be given by:

$$WA = \frac{\sum_{i=1}^{4} r_i f_i}{\sum_{i=1}^{4} r_i} \quad (1)$$

where, r_i is the 4-points Rensis Likert's attitudinal rating and f_i is the frequency of occurrence of r_i . Let WA_1 be weighted average in quartile 1 (Q_1) and WA_2 be weighted average in quartile 4 (Q_4). It follows that the DP is given by:

$$DP = WA_1 - WA_2 \quad (2)$$

The theorems that underpin the foregoing discriminative power concept are briefly presented here.

Theorem 1: Let R represent reordered data matrix in merit order of respondent's scores. If all entries $a_{ij} \in R$ are entirely uniform, the resulting DP = 0, leading to conclusiveness or consensuality or complete agreement.

Proof: From Eq. (1) we have

$$WA = \frac{\sum_{i=1}^{4} r_i f_i}{\sum_{i=1}^{4} r_i}$$

Let WA_1 be weighted average in quartile 1 (Q_1) and WA_2 be weighted average in quartile 4 (Q_4):

$$WA_1 = \frac{\sum_{i=1}^{4} r_{1i} f_{1i}}{\sum_{i=1}^{4} r_{1i}};\ also\ \mathrm{WA}_2 = \frac{\sum_{i=1}^{4} r_{2i} f_{2i}}{\sum_{i=1}^{4} r_{2i}}$$

Since, $r_{1i} = r_{2i}$ on account of uniform entries of R, then

WA_1-WA_2 = 0 (infimum).

Theorem 2: Let all elements of $Q_1 \subset R$ be 4 and those of $Q_4 \subset R$ be 1. Then the resulting DP is a Supremum leading to controvertibility.

Proof: Let $a_{ij} \in R$ be uniform and consider j^{th} question. Also let WA_1 be weighted average in quartile 1 (Q_1) and WA_2 be weighted average in quartile 4 (Q_4):

$$WA_1 = \frac{\sum_{i=1}^{4} r_{1i} f_{1i}}{\sum_{i=1}^{4} r_{1i}};\ also\ \mathrm{WA}_2 = \frac{\sum_{i=1}^{4} r_{2i} f_{2i}}{\sum_{i=1}^{4} r_{2i}}$$

Since, $r_{1i} = 4r_{2i}$ on account of uniform entries of R, then $WA_1 = WA_2$. Therefore, DP = $3WA_2$.

Table 3: Frequency table for Q1 of sample 1.

S/N	Rating (r)	Frequency (f)	(rf)
1	4	0	0
2	3	3	9
3	2	0	0
4	1	0	0

Table 4: Frequency table for Q4 of sample 1.

S/N	Rating (r)	Frequency (f)	(rf)
1	4	0	0
2	3	0	0
3	2	0	0
4	1	3	3

Theorem 3: Let all elements of $Q_1 \subset R$ be r_1 and those of $Q_4 \subset R$ be r_2 where, r_1-r_2 = 1. Then the resulting DP is a middling signifying inconclusiveness or is up in the air.

Proof: Let WA_1 be weighted average in quarter 1 (Q_1) and WA_2 be weighted average in quarter 4 (Q_4):

$$WA_1 = \frac{\sum_{i=1}^{4} r_{1i} f_{1i}}{\sum_{i=1}^{4} r_{1i}}; \; also \; \mathrm{WA}_2 = \frac{\sum_{i=1}^{4} r_{2i} f_{2i}}{\sum_{i=1}^{4} r_{2i}}$$

$$Since \; \mathrm{f}_{1i} = f_{2i} \; \text{and} \; \mathrm{r}_{1i} - r_{2i} = 1 \; \text{then}, \; \mathrm{WA}_1 - WA_2 = \frac{\sum_{i=1}^{4} f_{1i}(r_{1i} - r_{2i})}{\sum_{i=1}^{4} f_{1i}} = 1$$

Thus the DP depends on the difference between ratings of the upper and lower quartiles. The maximum difference of 3 is obtained for controvertibility. In the second case, the minimum difference of 0 is found for consensuality. In the third case, the middle of the road difference of 1 is got for up in the air or unresolved or open case or inconclusiveness (Igboanugo and Nwobi-Okoye, 2012).

DP calculations

(i) Obtain weighted total (WT) of the first and fourth quartiles

$W = Scores \times number \text{ of persons who tick that score}$

(ii) Obtain weighted mean (WM) of the first and fourth quartiles

$$WM = \frac{WT}{Number \text{ in the group}}$$

(iii) Obtain DP's of each question

$$DP = WM \; of \; \text{first quartile - WM of the fourth quartile}$$

2.3 Representation of the DP Profile

A presentation of the DP values on a bar chart can be seen in Figure 1, this highlights the DP values as bars.

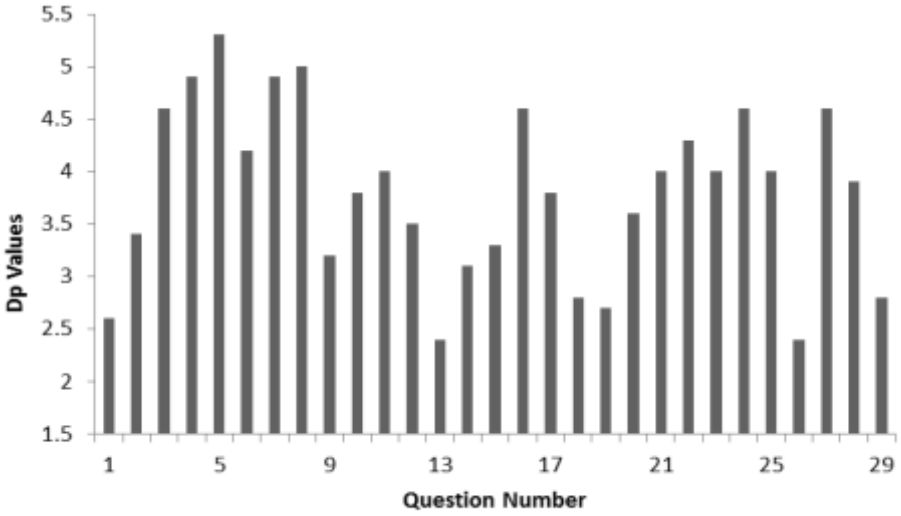

Figure 1: DP Values for the twenty nine variables (factors) affecting Alkyd Resin Production.

3.0 RESULTS AND DISCUSSION

The DP values were plotted as bar chart as shown in figure 1 and interpretations rendered. The DP-values are segmented as follows:

3.1 Lower bandwidth: $2.4 < DP \leq 3.0$

In this regime, the respondents are in total agreement on the issue considered. In other words there is consensuality.

Table 5: Lower bandwidth DP values of variables that affect the production process of rubber seed oil based alkyd resin preparation.

Variable Number	Description	DP Value
1	Catalyst	2.6
13	Absence of catalyst	2.4
18	Temperature	2.8
19	Water resistance	2.7
26	Length of resin	2.4
29	Acidic content	2.8

3.2 Middle bandwidth: $3.1 < DP \leq 4.0$

In this group, the respondents are fairly in agreement on the subject matter.

Table 6: Middle bandwidth DP values of variables that affect the production process of rubber seed oil based alkyd resin preparation.

Variable Number	Description	DP Value
2	Excellent odour	3.4
9	Gloss	3.2
10	Fast drying	3.8
11	Film hardness	4.0
12	Chemical resistance	3.5
14	Environmental impact	3.1
15	Bio-stability of alkyd	3.3
17	Presence of oxidizing agent	3.8
20	Resin thickness	3.6
21	Universal availability	4.0
23	Polyol	4.0
25	Iodine value	4.0
28	Gloss retention	3.9

3.3 Upper bandwidth: DP > 4.0

In this category, the respondents are weakly in agreement with what was put forth.

Table 7: Upper bandwidth DP values of variables that affect the production process of rubber seed oil based alkyd resin preparation.

Variable Number	Description	DP Value
3	Heat bleach ability	4.6
4	Viscosity	4.9
5	Colour	5.3
6	Percentage yield	4.2
7	Flexibility	4.9
8	Durability	5.0
16	Storage property	4.6
22	Low cost	4.3
24	Esterification	4.6
27	Resistance to abrasion	4.6

The DP values in Table 5 are very low suggesting that there is high level of agreement among respondents that these identified variables can affect the manufacturing process of rubber seed based alkyd resin. In other words, there is complete agreement.

In Table 6, the respondents are fairly in agreement with certain attributions made concerning these variables. The implication of this is that any decision reached about this cluster is therefore considered fairly conclusive. In Table 7 the DP values are high; the variables clustered therein are relatively controversial, as the respondents are weakly in agreement with

the attributions made concerning such variables. This however showed a case of controvertibility.

The DP-values obtained in the course of this research work has enabled us to appreciate the main factors that are very influential to the manufacturing process of rubber seed oil based alkyd resin. In particular their relative influence is indicative of the magnitude of the DP-values. Besides, the opinion discrimination analytical modelling approach developed using DP-values, have been helpful in dealing with several factors that are individually or collectively influence the manufacturing process of rubber seed oil based alkyd resin suitable for small and medium scale enterprises especially in developing countries where manufacturing processes are thwarted by economic depression.

4.0 CONCLUSION

This study has been able to apply Opinion discrimination Analysis that incorporated Rensis Likert's 5-point attitudinal scale model and Discriminative Power Index in order to understand the dynamics of the mutual interaction of the factors that influence the manufacturing process of rubber seed oil based alkyd resin for use in surface coating industry. The manufacturing industries of rubber seed oil based alkyd resin are in concordance that these variables contribute immensely to quality of outputs evidenced by the low DP-values obtained. This empirical evidence is supportive to the objectives of the study.

Investigation made through this study also revealed that it takes a substantial amount of insight, ability, and experience to establish individual and collective actions of factors that are effective in rubber seed oil based alkyd resin production process.

The opinion discrimination modeling approach offered in this study however appears to be effective in dealing with the problem of identifying key factors associated with the manufacturing process of rubber seed based resin.

Finally, the theory underpinning the discriminative power index is developed and demonstrated.

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