X-Ray Diffraction Analysis of the Microscopies of Some Corrosion-Protective Bitumen Coatings

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Abstract: *The most important versatile and widely used method for corrosion protection of steelworks is by paint or organic coatings. Information about microscopy of a protective coating is essential to understand the basic determinants of its attributes and improvement requirements. Bitumen has been an important material for the protection of steelworks in the world's petroleum or other chemical and water industries. Bitumen is however attended with some undesirable characteristics and it can vary widely in quality from one source to another. A previous study has shown that Nigeria has abundant bitumen resources for sustained exploitation as common and economical coat-inhibitors of steel corrosion in her economy. In this paper, the micro-structural make-ups of coatings produced with bitumens harvested from the country's critical bitumen resources by a bath dipping process at a temperature of 230^{0}C and cooled to room temperature are investigated through the analysis. The results show that about 3.75 to 4.847% of each coating is constituted by five to seven of 14 listed different mineral phases; and there is variation in quantity and types of these phases even in coatings produced at the same temperature with bitumen from the same source.*

Keywords: *Corrosion of steelworks, protective coatings, Nigerian bitumens, bath-dipping process, microscopy, XRD analysis.*

I. INTRODUCTION

The levels of material structure which are of greatest interest in material science and engineering are the microstructure, the substructure and the crystal structure. The mechanical, physical, chemical, electrical and magnetic properties of a material such as strength, wear resistance, hardness, corrosion resistance, high and low temperature behaviours; defects such as porosities, segregations, discontinuities, etc are strongly dependent on its micro-structure (Raghavan, 1990; INTERNET, 2012b). Microscopy is the technical field of using microscopes to view samples that cannot be seen with the unaided eye, to understand and provide basic information on their microstructures. There are three well-known branches of microscopy: optical, electron, and scanning probe microscopy. Characteristics distances observable by optical microscopy are around 100nm, by electron microscopy 0.15 – 2.5nm, and by X-ray diffraction 0.01nm; and scanning probe microscopy has minimum scan-spot size and other limitations resolution to about 1nm. The majority of our knowledge about atomic positions and intermolecular distances is gained from X-ray diffraction measurement. X-ray Diffraction (XRD) is a high-tech, non-destructive technique for analyzing a wide range of materials including fluids, metals, minerals, polymers, catalysts, plastics, pharmaceuticals, thin-film coatings, ceramics, solar cells and semi conductors. The technique finds innumerable practical applications in various industries, including microelectronics, power generation, aerospace, and many more. The XRD analysis can easily detect the existence of defects in a particular crystal, its resistance level to stress, its texture, its size and degree of crystallinity and virtually any other variable relating to the sample's basic structure (Hull and John, 1989; Bodor, 1991; INTERNET, 2012b).

Corrosion of carbon steel is a prime corrosion problem in all quarters and the commonest, most versatile and widely used method to counteract it by paint or organic coatings. It is estimated that about 90% of all steel are corrosion-protected by paints or organic coatings. The quality of a protective coating however, depends greatly on the quality of the coating material and method. Bitumen is an organic material that has been in use for corrosion protection of transmission pipelines and other aspects of plants in the world's petroleum or other chemical and water industries; and coatings based on it show excellent resistance to industrial pollution (Guma et al, 2010; 2011a-b; 2012a-b). However, bitumen is in most cases not used in its original form, but modified or supported because of certain undesirable characteristics of the material which include (Jackson and Ravindra, 1996):

i. Its ability to exist in solid, semisolid, or very high and low vicious liquid state; and change it hardness or consistency with temperature.
ii. Its not being mechanically tough enough to withstand much wear or stress.
iii. Its ability to crack under cold weather.
iv. Its poor resistance to organic solvents.
v. The dependence of its engineering properties on temperature, duration of loading, and the applied stress.

Nigeria's economy is petroleum-dependent and a lot of wastages occur in it through the corrosion process. The country has abundant bitumen resources for sustained exploitation as common, economical, and effective coat-inhibitors of steel corrosion in her economy. Test-evaluation of corrosion resistance of five different coatings of 0.81 to 1.46mm thicknesses with each of three harvested bitumens from the country's critical bitumen resources with assigned identification names OndoS-A, OndoS-B, and KPB was carried out to substantiate that fact. OndoS-A and OndoS-B were natural bitumens collected from rich and clear deposits in a waterlogged surface area, and underground through a standard extraction hole respectively at Agbabu village in Ondo State of the country while KPB was a synthetic bitumen produced with the blend of

Nigerian crude and Iran's Basara crude as feedstock at the country's most important synthetic bitumen outfit-Kaduna Refining and Petrochemical Company. The coatings were applied on low carbon steel specimens by a bath-dipping process at temperatures in the range of 170 to 230^{0}C and cooled to room temperature. The resistance of each coating to corrosion deterioration of each of the basic mechanical properties of low carbon steel was evaluated. It was found that the bitumens differed physioco-chemically in characteristics properties and, their coatings generally exhibited appreciable inhibition performances; and KPB coatings the highest performance while those of Ondo S-A the least. Moreover, as coating thickness decreased with increase in the coating temperature, the corrosion protection performance decreased (Illston et al, 1979; Pain.Dec.Con., 1995; Alwan, 2010; Guma et al (2010, 2-2011a-b, 2012a); INTERNET, 2012b). The prime objectives of this paper is therefore,

i. To understand the distinct microscopical make-ups of the bath-dip produced coatings with KPB and Ondo S-A which exhibited the highest and lowest corrosion inhibition performances respectively by proper XRD analysis.
ii. To present the information for consideration in any methodical modification strategy of bitumens of such characteristic structures and the coating method to improve the coatings for better service performance, and relevant researches on bitumen and other coating technologies.

II. METHODOLOGY

Principles of X-ray diffraction analyses

The concept of X-ray diffraction analysis originates from the established fact that when parallel X-ray 1, 2, 3, 4, 6 of the same wavelength produced by some source are linearly incident on different crystal planes of atoms of a sample separated by a distance 'd' from one another as shown in figure 1 below, there is constructive.

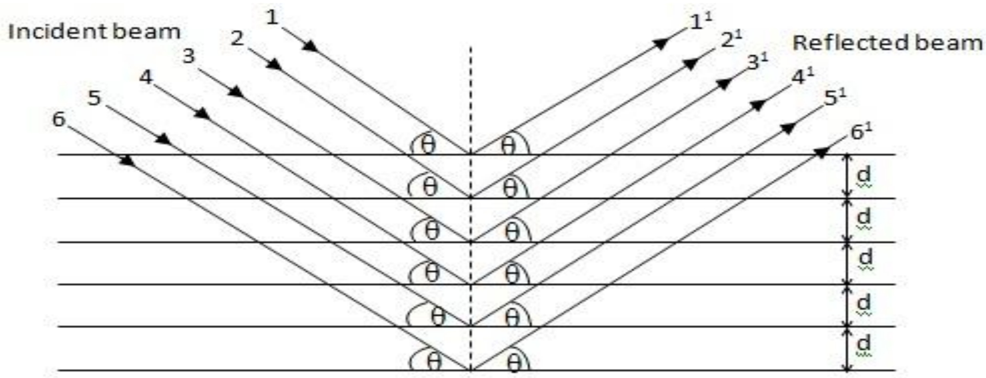

Fig. 1: X-ray diffraction pattern

interference of respectively diffracted (reflected) X-ray 1^1, 2^1, 3^1, 4^1, 6^1,… at an angle θ with each plane on which the ray is incident. In other words the rays are in phase and there is resultant energy leaving the sample. The condition for which there is constructive but not destructive interference has been determined and expressed in Bragg's Law (Raghavan, 1990; Bodor, 1991) as,

$2d\sin\theta = n\lambda$ …………….1

Where; n = 1, 2, 3, 4, …, and λ is the wavelength of the X-ray. The greater the value of λ the larger is the value of θ, while the greater the value of d, the smaller is θ for a given λ. If λ is known and measured, then the value of n/d follows, and if the order can be found, the value of the spacing (d) of the reflecting planes is determined. By putting together the information on various sets of reflecting planes obtained in this way with the X-ray spectrometer, the first crystal structure were made. This follows that properly diffracted rays by atoms of crystals of any materials sample in accordance to Bragg's law can be used to analyze such sample based on the information obtained from the rays. A material that contains various structural discontinuities or inhomogenities will have them manifested in its degree of crystallinity at their locations and will be revealed in its microscopy by the energy intensities of the diffracted rays. This is because crystal atoms of the same size and nature will always produce diffracted X-rays of the same nature and intensities, while those of different sizes and natures will produce different diffraction information. XRD analysis is performed with an automated diffractometer and the sample data can be analyzed by the search/match and accept method using a computerized software with library of diffraction information on different inorganic, organic, and crystalline phases (Raghavan, 1990; Bodor, 1991; INTERNET, 2012c).

The mechanical assembly of the diffractometer that makes up the sample holder, detector arm and associated gearing is referred to as the goniometer. There are two types of goniometer, the THETA (θ) and 2-THETA (2θ) goniometers, but the 2-THETA, goniometer has better accuracy over the THETA when θ is small and is most widely used. For example, Figure 2 below shows the 2-THETA Bragg Brentano goniometer and its parts arrangement, with the sample in position. The X-ray tube and the detector of the goniometer can both be made to move simultaneously over the angular range 2-THETA.

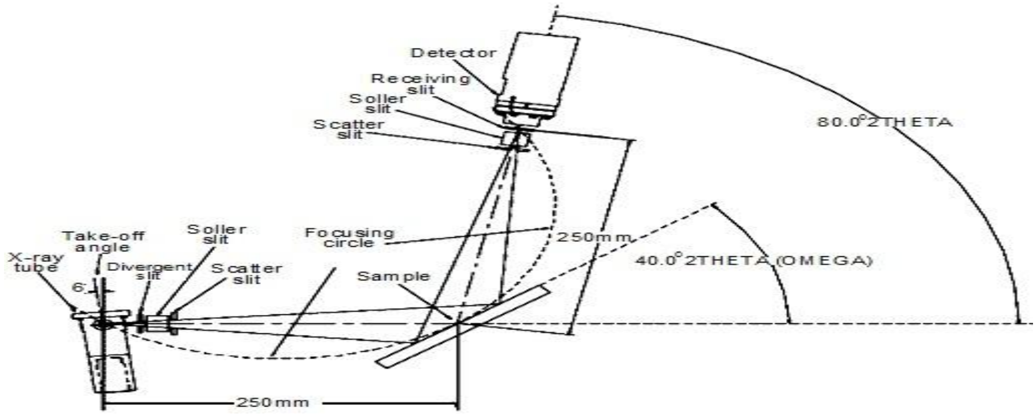

Fig. 2: The Bragg Brentano 2-THETA goniometer (INTERNET, 2012a).

Materials and Facilities

The main materials and facilities used were as follows:

i. The remaining bitumen samples of Ondo S-A, and KPB which were used by Guma et al (2010, 2011a-b, 2012)
ii. The Japanese-made Shimadzu-1200 model diffractometer with complete accessories
iii. A Bunsen burner
iv. A mercury-in-glass thermometer with a measuring range of up to 360^0C
v. A with-handle steel cup
vi. A thin-lip crucible tong

Specimen preparation and XRD Analysis

A portion of the KPB was detached in a reasonable quantity with a steel spoon and the end with the bitumen placed inside the cup. The thermometer was inserted into the bitumen. The cup was heated with the Bunsen burner by gas-firing and control to the thermometer-monitored temperature of 230^0C. This caused most of the bitumen on the spoon to drain off into the cup and the spoon was removed. The specimen loading glass slide of the diffractomer's goniometer was held with the tong and about 75% of it dipped in the bitumen bath at that temperature for 30 seconds and withdrawn and allowed to cool to room temperature for 30 minutes to produce coating (No. 1) of KPB on it in accordance to Illston et al, 1979; Pain.Dec.Con., 1995; Guma et al (2010, 2011a-b, 2012).

The other part of the specimen slide that was not dipped in the heated bitumen was used to hold it in the goniometer's slide attachment slit. The XRD was taken at room temperature using the diffractometer with counter monochromatic Cu-Kα radiation (from a Cu tube) of wavelength-0.15406nm. The voltage and current settings were 40KV and 30mA, respectively. The coating was examined in a continuous mode over the maximum angle range of the goniometer from $2\theta = 0$ to 120^0. The scanning speed, sampling pitch and preset time were $2\theta = 7^0$/min, 0.02 and 0.17sec respectively.

With these, the diffractogram, reference peak intensities, reference high and low intensity peaks and, the performed search/match and accept information on the coating; were produced with the diffractometer's computer. To investigate any microstructural variation in coatings with bitumen from the same source, the procedure was repeated with another portion of KPB after properly cleaning the cup with kerosene, water and detergent to produce another coating (No. 2) with another portion of KPB. The coating was then scanned with a range of 2θ from 3 to 60^0 which also covered the major characteristic reflection for all conditions in the coating; and scan speed of 5 deg/min, sampling pitch of 0.02 deg, and preset time of 0.24sec respectively. The described test procedure for coating (No.1) with KPB was similarly repeated with Ondo S-A after similarly cleaning the cup off of the KPB portion.

III. RESULTS AND DISCUSSION

The diffractograms for KPB coating Nos. 1 & 2, and Ondo S-A and an example is shown for the coating No.1 in Figure 3. The scan peak counts intensities for KPB coating (No. 1 & 2) and Ondo S-A were also obtained and an example is shown for the case of KPB coating No. 1 in Table 1, together with the corresponding 2θ scan, observed d-spacing in Angstrom, intensity in counts, intensity match ratio (I/II), and Full Width at Half Maximum at lower angle side (FWHM). The obtained reference peaks of high and low intensities for KPB coating (No. 1 & 2), and Ondo S-A with the diffractometer's computer software were also obtained and an example is shown in Figure 4 for coating No.1. The overall print out result for coating Nos 1&2, and Ondo SA are shown respectively in Tables 2, 3, and 4; showing the scale factor (S), line match ratio (L), density (Dx), percentage composition by weight (Wt %) and intensity (I) for the observed microstructure.

Microstructural analysis of the coating shows that the as-prepared Ondo S-A coating is constituted of five different mineral phases which are principally; Lead Oxide, Magnesium Silicate Hydroxide, Chromium Nitride, Magnesium Silicate Hydroxide, and Calcium Silicate Hydroxide Hydrate totaling to the tune of 3.75% of the scanned area. Results for KPB coating No. 1 show the presence of Sucrose, Sucrose Octaacetate, Nickel Iodide Triethylamine N-oxide, Codeine Phosphate Dihydrate and Barium Neodymium Titanium Oxide mineral phases totaling to the tune of 4.374% within the scanned area. The identified principal mineral phases in KPB coating No. 2 are Hcl, Zirconium Oxide, Codeine Phosphate Dihydrate, Nickel Iodide Triethylamine N-oxide, Sucrose Octaacetate and Sodium Aluminium silicates totaling to a 4.847 within the scanned area.

The difference between the as-produced KPB coatings (Nos. 1 & 2) is in the presence or absence of the Sucrose, Iron Chromium Oxide, Sodium Aluminum Silicate, Hcl, Barium Neodymium Oxide in one or the other. This means that, there are some microstructural variations in the as-produced coatings even with bitumen from the same source.

IV. CONCLUSION

Bitumens are usually coat-applied within the temperature range of 150 – 250^{0}C and in the oxidized form for corrosion protection of steelworks (Illston et al, 1979; Pain.Dec.Con., 1995). A previous study has shown that coatings of 0.81 to 1.73mm thicknesses produced by the bath-dipping process with bitumens harvested from critical sources in Nigeria can provide appreciable or complete inhibition of corrosion deterioration of the basic mechanical properties of low carbon steel. XRD is a versatile, non-destructive method that will reveal detailed information about the chemical composition, crystallography and microstructure of all types of natural and manufactured materials; that cannot be revealed by the optical and most other methods of microscopy analysis. XRD analyses of microscopies corrosion-protective coatings of bitumens harvested from different critical sources in Nigeria which were produced at 230^{0}C and subsequently cooled to room temperature has been conducted. The results indicate that 3.75 to 4.847% of each of the coatings consists of five to seven of 14 listed distinct mineral phases and coatings of bitumens from even the same source will have variation in these phases.

V. RECOMMENDATION

The information presented in this paper is recommended to be considering in any methodical modification or improvement strategy in utilizing the abundant Nigerian bitumen resources for corrosion protection of steelwork in her petroleum-dependent economy or elsewhere, and for relevant research purposes.

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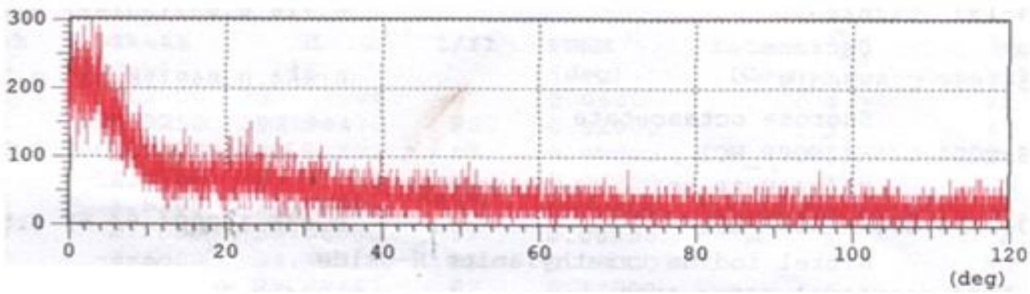

Fig. 3:Diffractogram Obtained with KPB Coating No. 1

Strongest 3 peaks

no.	peak no.	2Theta (deg)	d (A)	I /I1	FWHM (deg)	Intensity (Counts)	Integrated Int. (Counts)
1	10	4.0000	22.07195	100	0.40000	6	110
2	7	2.5600	34.48329	83	0.08000	5	33
3	2	0.8250	106.99472	83	0.11000	5	41

#Peak Data List

Peak no.	2Theta (deg)	d (A)	I/I1	FWHM (deg)	Intensity (Counts)	Integrated Int. (Counts)
1	0.2500	353.07979	67	0.06000	4	22
2	0.8250	106.99472	83	0.11000	5	41
3	1.1600	76.09602	67	0.08000	4	21
4	1.4700	60.04918	33	0.06000	2	6
5	1.8100	48.76992	33	0.14000	2	32
6	2.2600	39.06000	17	0.00000	1	0
7	2.5600	34.48329	83	0.08000	5	33
8	2.9550	29.87467	67	0.17000	4	37
9	3.4800	25.36881	17	0.00000	1	0
10	4.0000	22.07195	100	0.40000	6	110
11	4.7200	18.70653	17	0.00000	1	0
12	5.1600	17.11235	50	0.04000	3	21
13	5.6550	15.61551	33	0.03000	2	3
14	5.9400	14.86691	50	0.04000	3	13
15	6.3200	13.97384	83	0.04000	5	31
16	6.9700	12.67207	50	0.06000	3	25
17	7.5350	11.72309	33	0.09000	2	13
18	8.2300	10.73461	33	0.14000	2	15
19	9.0200	9.79613	17	0.00000	1	0
20	11.0600	7.99341	50	0.04000	3	18
21	11.5500	7.65537	33	0.06000	2	19
22	12.0600	7.33276	33	0.08000	2	16
23	12.3600	7.15544	33	0.16000	2	25
24	12.7000	6.96463	17	0.00000	1	0
25	13.4150	6.59499	67	0.19000	4	54
26	13.7200	6.44905	17	0.00000	1	0
27	14.0200	6.31173	50	0.04000	3	17
28	14.3200	6.18017	17	0.00000	1	0
29	14.7450	6.00298	50	0.05000	3	21
30	15.4500	5.73061	50	0.06000	3	24
31	15.9800	5.54172	33	0.28000	2	44

32	16.38.50	5.40564	50	0.05000	3	14
33	16.6400	5.32337	17	0.00000	1	0
34	17.6000	5.03511	50	0.04000	3	18
35	18.3000	4.84405	50	0.04000	3	20
36	18.7600	4.72630	50	0.04000	3	19
37	19.0800	4.64775	17	0.00000	1	0
38	19.4000	4.57180	33	0.08000	2	9
39	20.5700	4.31433	50	0.06000	3	16
40	20.0400	4.25904	50	0.08000	3	24
41	21.2400	4.17972	17	0.00000	1	0
42	21.7400	4.08471	50	0.04000	3	19
43	21.9000	4.04428	50	0.04000	3	18
44	22.2200	3.99755	33	0.12000	2	27
45	22.6900	3.91579	83	0.10000	5	68
46	23.3400	3.80819	33	0.16000	2	37
47	23.5200	3.77905	50	0.04000	3	11
48	23.8900	3.72175	33	0.14000	2	25
49	24.2200	3.67178	17	0.00000	1	0
50	24.5400	3.62462	50	0.04000	3	17
51	25.0400	3.55337	17	0.00000	1	0
52	25.5700	3.48090	50	0.06000	3	29
53	26.1300	3.40756	50	0.06000	3	28
54	26.6600	3.34101	50	0.08000	3	24
55	27.2700	3.26764	33	0.22000	2	26
56	27.7500	3.21220	33	0.10000	2	21
57	28.1900	3.16306	33	0.06000	2	17
58	28.7600	3.10165	50	0.04000	3	19
59	29.3000	2.04570	17	0.00000	1	0
60	27.7400	3.00164	50	0.04000	3	21
61	30.3200	2.94552	17	0.00000	1	0
62	30.9000	2.89155	67	0.20000	4	72
63	31.2800	2.85728	50	0.04000	3	17
64	31.6700	2.82298	50	0.10000	3	42
65	31.9800	2.79632	33	0.04000	2	17
66	32.2500	2.77352	67	0.14000	4	57
67	32.6600	2.73973	17	0.00000	1	0
68	33.0500	2.70819	50	0.06000	3	36
69	33.9200	2.64069	33	0.08000	2	24
70	34.3000	2.61230	67	0.12000	4	48
71	34.8700	2.57089	33	0.22000	2	44
72	35.5100	2.52601	33	0.06000	2	16

73	35.9000	2.49946	17	0.00000	1	0
74	36.0800	2.48740	33	0.04000	2	19
75	36.2400	2.47678	50	0.04000	3	23
76	37.1600	2.41755	1	0.00000	0	0
77	38.0600	2.36243	50	0.08000	3	32
78	38.5900	2.33119	33	0.06000	2	14
79	38.9000	2.31332	17	0.00000	1	0
80	42.1900	2.14023	33	0.06000	2	9
81	43.5600	2.07604	17	0.00000	1	0
82	44.2300	2.04613	33	0.06000	2	11
83	44.7800	2.02227	17	0.00000	1	0
84	46.1200	1.96658	50	0.08000	3	20
85	46.7400	1.94193	17	0.00000	1	0
86	52.0400	1.75593	33	0.04000	2	8
87	52.4800	1.74224	50	0.04000	3	19
88	53.2400	1.71915	17	0.00000	1	0
89	54.5400	1.68120	33	0.16000	2	27
90	55.0000	1.66822	33	0.04000	2	9
91	55.8800	1.64402	17	0.00000	1	0
92	61.1200	1.51503	33	0.08000	2	21
93	62.6600	1.48144	17	0.00000	1	0
94	66.5100	1.40472	33	0.14000	2	22
95	66.7700	1.39988	33	0.10000	2	13
96	67.3600	1.33904	17	0.00000	1	0
97	68.4000	1.37044	33	0.08000	2	10
98	70.5200	1.33434	17	0.00000	1	0
99	72.1400	1.30831	33	0.04000	2	9
100	72.8200	1.29776	17	0.00000	1	0
101	77.2500	1.23402	33	0.14000	2	19
102	77.5400	1.23013	17	0.00000	1	0
103	84.2000	1.14897	50	0.04000	3	24
104	84.1500	1.14291	33	0.18000	2	53
105	86.3000	1.12632	1	0.00000	0	0
106	87.7800	1.11110	33	0.04000	2	11
107	88.6400	1.10252	17	0.00000	1	0
108	90.0500	1.08889	33	0.10000	2	21
109	90.8800	1.08110	17	0.00000	1	0
110	91.5400	1.07502	33	0.08000	2	13
111	91.8000	1.07265	17	0.00000	1	0
112	100.0800	1.00493	33	0.04000	2	10
113	100.4000	1.00262	17	0.00000	1	0

114	101.8700	0.99210	33	0.26000	2	42
115	102.5600	0.98730	17	0.00000	1	0
116	104.4700	0.97441	33	0.26000	2	47
117	104.8600	0.97185	50	0.12000	3	32
118	105.4100	0.96829	33	0.18000	2	23
119	105.8200	0.96566	17	0.00000	1	0
120	112.2600	0.92773	33	0.08000	2	13
121	112.5600	0.92611	17	0.00000	1	0
122	114.4000	0.91641	33	0.04000	2	14
123	114.9800	0.91344	17	0.00000	1	0
124	115.6000	0.91031	33	0.08000	2	15
125	115.9200	0.90872	17	0.00000	1	0
126	117.5100	0.90098	33	0.18000	2	30
127	117.9200	0.89904	1	0.00000	0	0
128	118.2600	0.89744	33	0.04000	2	13
129	118.7600	0.89511	1	0.00000	0	0
130	119.2700	0.89277	33	0.14000	2	31

Table 1: Reference Peak Intensities for KPB Coating No. 1

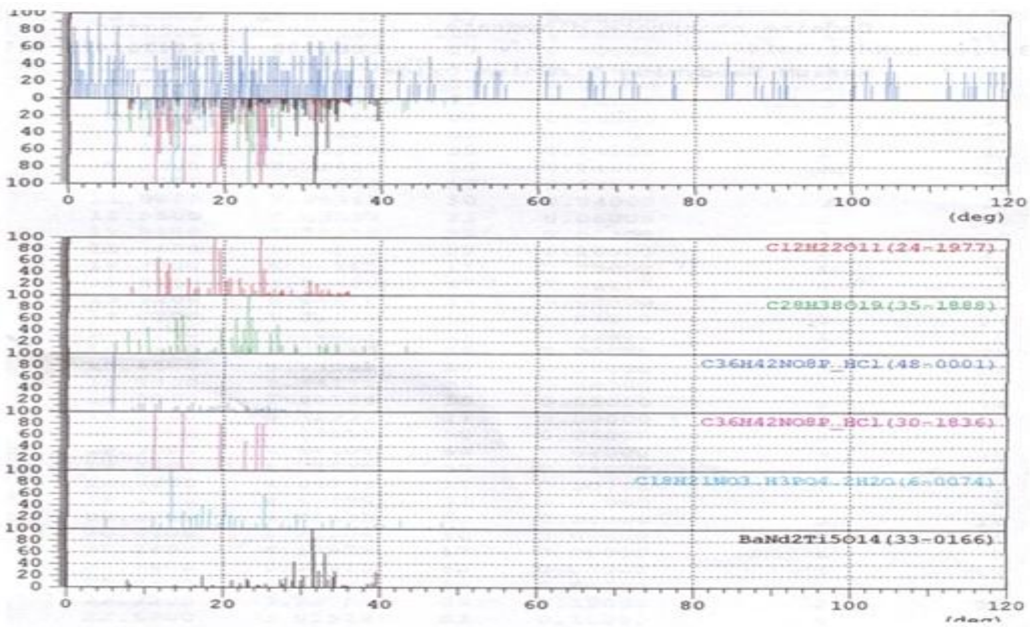

Fig. 4: Reference Peaks of High and Low Intensities for KPB Coating No. 1

<Entry Card>

No.	Card	Chemical Formula / Chemical Name (Mineral Name)	S / Dx	L / WT% S.G.	d	I
1	24-1977	C12H22011 / Sucrose	0718	0.833 (35/42) ------	0.799 ----- 0.666 ---------	
2	35-1888	C28H38019 / Sucrose octaacetate	0.834	0.848 (28/33) ------	0.745-------0.632 ---------	
3	48-0001	C36H42NO8P_ HCL	0.838	0.838 (25/30)	0.712-------0.593	

		C36H42NO8P_HCL (C36H42NO8P_HCL)	------		---------
4	30-1836	C36H42NO8P_HCL	0.476	1.000 (6/6)	0.593-------0.593
		Nickel iodide triethylamine N-oxide		------	---------
5	6-0074	C18H21NO3 .H3PO4. 2H2O	0.924	0.775 (31/40)	0.733------0.568
		Codeine phosphate dehydrate		------	---------
6	33-0166	BaNd2Ti5014	0.833	0.714 (30/42)	0.792------0.566
		Barium Neodymium Titanium Oxide		------	---------

Table 2: Search/Match and Accept Result for KPB Coating No. 1

<Entry Card>

No.	Card	Chemical Formula / Chemical Name (Mineral Name)	S / Dx	L / WT%	d I / S.G.
1	48-0001	C36H42NO8P_HCl	0.874	0.767 (23/30)	0.741------0.568
		C36H42NO8P_HCl (C36H42NO8P_HCl)	------		---------
2	22-1025	Zr3O	0.383	0.750 (12/16)	0.702------0.526
		Zirconium Oxide		------	---------
3	6-0074	C18H21NO3. H3PO4. 2H2O	0.706	0.775 (31/40)	0.672------0.521
		Codeine phosphate dehydrate		------	---------
4	30-1836	C18H21NO3. H3PO4. 2H2O	0.300	0.833 (5/6)	0.622------0.519
		Nickel iodide triethylamine N-oxide		------	---------
5	24-0511	C18H21NO3. H3PO4. 2H2O	0.460	0.700 (7/12)	0.739-----0.517
		Iron Chromium Oxide		------	---------
6	35-1888	C28H38019	0.652	0.758 (25/33)	0.683------0.517
		Sucrose octaacetate		------	---------
7	10-0393	Na (Si3A1) 08	0678	0.738 (31/42)	0.688------0.508
		Sodium Aluminum Silicate (Albite, disorder		------	---------

Table 3: The Search/Match and Accept Result for KPB Coating No. 2

<Entry Card>

No.	Card	Chemical Formula / Chemical Name (Mineral Name)	S / Dx	L / WT%	d I / S.G.
1	8-0019	Pb304	0.715	0.795 (31/39)	0.812 ----- 0.646
		Lead Oxide (Minium, syn)		-----	--------
2	13-0558	Mg3Si4010 (OH)2	0.614	0.900 (27/30)	0.708------ 0.637
		Magnesium silicate hydroxide (Talc-2/ITM/	-----		-------
3	11-0065	CrN	0.444	0.875 (7/10)	0.720------0.630
		Chromium Nitride (Carlsbergite, syn)		------	-------------
4	29-1493	Mg3Si4010 (OH)2	0.463	0.800 (12/15)	0.759 -----0.607
		Magnesium Silicate Hydroxide (Talc-2/ITM	-------		-----------------
5	29-0382	Ca14Si24O58 (OH)8.2H2O	0.729	0.786 (33/42)	0.752-----0.591
		Calcium Silicate Hydroxide Hydrate (Trusc	--------		-----------

Table 4: Search/Match and Accept Result for Ondo S-A Coating