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Comparative Study of Quality Control Parameters of Crystal 55 with Other Grade

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Abstract

The production of quality product (crystals) has been carried out to determine and compare the parameter of the Crystal 55 formulated with other grades such as 60, 65, 70, 85 and 90. This research presents the best quality product of different formulations of the PVC compounding (crystals) and the importance of the additive added during production. The materials used are polyvinylchloride resin (PVC resin), dioctal-phthalate (DOP), epoxy, chlorinated paraffin wax 44 (CPW 44), Mp 38 and satiric acid. Operations involved in the formulation were mixing, heating, cooling and extruding. The results obtained for different formulation of crystals at different temperature, color, heat effect and flexibility show that Crystal 55 has the best quality product among others. It was observed that as the temperature changes the color of the crystal changes as well as the flexibility. This is because the quantity of oil (DOP, CPW44 and Epoxy) to soften the materials (chemicals) is decreasing while the PVC resin is increasing.

Keywords: *Crystal formulation, compounding ingredients, temperature effect.*

Introduction

Polyvinyl chloride (PVC) resin is a material used in the production of pipes, cables wires, crystals (PVC compound), and pastes forming leather cloth in polymer industries (Meyers 1992). PVC crystal is produced by using chlorinated paraffin wax 44, epoxy, Di-octyl-phthalate (DOP), stearic acid, Mp 38 (basic lead carbonate) and polyvinyl chloride resin. Chlorinated paraffin waxes (CPW) are of two types (CPW 44 and CPW 52 containing 44% and 52% of chlorine, respectively). Although in the production of crystal, CPW 44 is often used because it is lighter than CPW 52 (Brady 1984, 1986).

In crystal production, the effect of heat is taken into consideration and the quantity of the additives added during production to form the desired product. The process of combining various additives and ingredients with the based polymers to produce a plastic formulation with improved characteristics is called compounding (Blackley 1996).

Polyvinyl chloride (PVC) is a tough, strong thermoplastic material which has excellent combination of physical and electrical properties. Due to the wide range of possible formulation it is difficult to make generalizations about the properties of PVC compounds. Mechanical properties are considerably affected by the type and amount of plasticilizer (Brady 1986; and Smee 1963).

It is important to note that the incorporation of small amounts of plasticizer, that is, less than 20% does not give compound of impact strength higher than that of unplasticized grades, in fact the impact strength appear to go through a minimum at about 10% plasticizer concentration. As a result of this behavior, lightly plasticized grade are used only when ease of processing is more important than in achieving a compound with good impact strength (Wikipedia 2008).

It is necessary, when considering PVC compounds for applications, that the ingredient of the PVC compounds does not affect the nature and properties of chemicals (additives). Ingredients of the PVC compounds are:

polymer, plasticizer, stabilizer, extender, lubricant, filler, pigment, polymeric processing aid and impact-modifier. Other miscellaneous materials used include: fire retardant, optical bleach and blowing agents (Austin 1984).

To make a quality and useful plastic materials, compounding ingredient must be added. Plasticizers reduce the viscosity and make sharing and forming easier. Also, it impact flexibility to the finished product. Unplasticized PVC is a rigid material whilst the plasticized material is flexible and even rubbery at high plasticizer loading (Wikipedia 2008).

Stabilizers improved the resistance of PVC against degradation by ultra-violet radiation and also retard the formation of color in unpigmented PVC compound. Extenders act as a supplement to plasticizer without serious adverse effects on the properties of the compound. Lubricants prevent sticking of the compound to processing equipment and also control the gelatin of powder blends while, fillers increase the hardness of a compound, improve electrical insulation properties and hot deformation resistance. Meanwhile, polymeric impact modifier reduces the difficulties in processing and for PVC compound to brittle for some application (Brydson 1971).

This research works aim at determining the effects of additives (compounding ingredients) added during the production (formation) in order to obtain a flexible product that will last longer in cold weather, snow and hash weather.

Methodology

Table 1 provides a list of materials used. Below is a description of the PVC compounds:

Formation of PVC compound of grade 55 (crystal 55), 100.0 kg:

- PVC resin 56.23 kg
- DOP 33.73 kg
- CPW 44 7.50 kg
- Mp 38 1.12 kg
- Epoxy 1.12 kg
- Stearic acid 0.30 kg

Formation of PVC compound of grade 65 (crystal 65), 100.0 kg:

- PVC resin 58.43 kg
- DOP 31.15 kg
- Stearic acid 0.30 kg
- Mp 38 1.17 kg
- Epoxy 1.17 kg
- CPW 44 7.78 kg

Formation of PVC compound of grade 70 (crystal 70), 100.0 kg:

- PVC resin 71.22 kg
- DOP 24.92 kg
- Stearic acid 0.30 kg
- Mp 38 1.78 kg
- Epoxy 1.78 kg

Formation of PVC compound of grade 85 (crystal 85), 100.0 kg:

- PVC resin 73.85 kg
- DOP 22.15 kg
- Mp 38 1.85 kg
- Epoxy 1.85 kg
- Stearic acid 0.30 kg

Formation of PVC compound of grade 90 (crystal 90), 100.0 kg:

- PVC resin 76.10 kg
- DOP 19.80 kg
- Mp 38 1.90 kg
- Epoxy 1.90 kg
- Stearic acid 0.30 kg

Table 1. List of materials used.

Material	Source	Comment
Polyvinyl chloride resin (PVC)	Aldrich Chemical Co. Ltd., Gillingham, Dorset, England	Polymer
Di-octyl-phthalate (DOP)	-ditto-	Plasticizer
Chlorinated paraffin waxes	KRPC/NNPC, (CPW 44) Nigeria	Supplement
Epoxy	BDH Chemical Ltd., Poole, England	Co-stabilizer
Mp 38 (Basic lead carbonate)	Poole, England	Stabilizer
Stearic acid	Poole, England	Laboratory Reagent

Experimental Procedure

Polyvinyl chloride compound formation was carried out by mixing PVC, Mp 38 and stearic acid in the Bausano mixer to mix properly until the temperature rise to 70^{o}C. At 70^{o}C, DOP, CPW 44 and epoxy are added to soften the materials in the mixer. These were allowed to mix until the temperature rise to 110^{o}C. The mixture was allowed to cool for some minute before the required products are formed.

Results

The results obtained for the characteristics of PVC compound of grade 55, 65, 70, 85 and 90 at various temperature ranges are tabulated in Table 2.

Table 2. Characteristics of PVC compound of grade 55, 65, 70, 85 and 90 (crystals).

Characteristics	Crystal 55	Crystal 65	Crystal 70	Crystal 85	Crystal 90
Color	Water white	Pale yellow	Pink	Orange	Brown
Product output	Very high	High	Low	Very low	Very low
Temperature	125-141^{o}C	127–143^{o}C	129-145^{o}C	130–147^{o}C	131–148^{o}C
Flexibility	Very soft	Soft	Soft, little, strong	Strong	Hard, strong
Transparency	Transparent	Transparent	Less transparent	Less transparent	Less transparent
Burning rate	Very low	Low	High	High	Too high
Physical state	Smooth, flexible rubber	Smooth, Flexibility Rubber	Rough, rubber	Rough, rubber	Rough, rubber

The temperature ranges for PVC compound of grade 55 from zone 1 to zone 9 are:

Zone 1------125^{o}C
Zone 2 -----127^{o}C
Zone 3 -----129^{o}C
Zone 4 -----131^{o}C
Zone 5 -----134^{o}C
Zone 6 -----136^{o}C
Zone 7 -----138^{o}C
Zone 8 -----140^{o}C
Zone 9 -----141^{o}C

The color of Crystal 55 (PVC compound of grade 55) is water white. The rate of burning is very low, easy to compress than other grades like 65 and is a smooth, flexible rubber and transparent. The product output is very high.

The temperature ranges for PVC compound of grade 65 from zone 1 to zone 9 are:

Zone 1 -----127^{o}C
Zone 2 -----129^{o}C
Zone 3 -----131^{o}C
Zone 4 -----132^{o}C
Zone 5 -----134^{o}C
Zone 6 -----137^{o}C
Zone 7 -----139^{o}C
Zone 8 -----141^{o}C
Zone 9 -----143^{o}C

The color of Crystal 65 is pale yellow, the burning rate is higher than Crystal 55, is harder than Crystal 55, smooth, flexible rubber in nature and transparent. The product is better than crystal 70 but less than Crystal 55.

The temperature ranges for PVC compound of grade 70 from zone 1 to zone 9 are:

Zone 1 -----129^{o}C
Zone 2 -----131^{o}C
Zone 3 -----133^{o}C
Zone 4 -----135^{o}C
Zone 5 -----136^{o}C
Zone 6 -----139^{o}C
Zone 7 -----141^{o}C
Zone 8 -----143^{o}C
Zone 9 -----145^{o}C

The color of Crystal 70 is pink, the rate of burning is very high, easy to compress like Crystal 85, is harder than Crystal 65, rough, rubber in nature and less transparent.

The temperature ranges for PVC compound of grade 85 from zone 1 to zone 9 are:

Zone 1 -----130^{o}C
Zone 2 -----131^{o}C
Zone 3 -----133^{o}C
Zone 4 -----135^{o}C
Zone 5 -----137^{o}C
Zone 6 -----139^{o}C
Zone 7 -----142^{o}C
Zone 8 -----144^{o}C
Zone 9 -----147^{o}C

The color of Crystal 85 is orange, the rate of burning is higher than Crystal 70, easy to compress than Crystal 90, is harder than Crystal 70, rough, rubber in nature and less transparent. The product yield is very low compared to Crystal 70.

The temperature ranges for PVC compound of grade 90 from zone 1 to zone 9 are:

Zone 1 -----131^{o}C
Zone 2 -----132^{o}C
Zone 3 -----134^{o}C
Zone 4 -----136^{o}C
Zone 5 -----139^{o}C
Zone 6 -----141^{o}C
Zone 7 -----143^{o}C
Zone 8 -----145^{o}C
Zone 9 -----148^{o}C

The color of Crystal 90 is brown; the rate of burning is too high, even higher than other grades. Crystal 90 is not easy to compress because of the hardness of the material. It is the hardest of all crystals, rough, rubber in nature and less transparent. The product output is very low compared to Crystal 85.

Discussion

The results obtained for different formulation of PVC compounds (crystal) and at different temperature, color and flexibility are shown in Table 2. The same quantity (percentage) of stearic acid that is, 0.30kg used during the production process reduce thermal degradation of PVC, reduce load on the processing aid, impact external lubricity for processing and makes PVC crystals transparent.

It was observed from the results obtained for different formulations of PVC Compounds (crystals) at different temperatures that as the temperature change the color of the crystals changes as well. This is because the quantity (percentage) of oil (DOP, CPW 44 and Epoxy) used to soften the compounds (crystals) were decreased while the PVC resin increased.

When the flexibility of Crystal 55 was compared to the crystals of other grades such as 65, 70, 85 and 90, it was observed that crystal 55 was very soft; may be as result of large quantity of oil added to 56.23kg of PVC resin. And Crystal 90 with least quantity of oil added to 76.0kg of PVC resin becomes more strong and hard.

The temperature variation shows the effect of heat on the product. The lower the temperature, the lower the effect of heat on the materials (chemicals) and the higher the temperature, the higher the effect of heat on the materials (chemicals) which caused changes in color and burning of the final product as observed in the crystal of other grades such as 65, 70, 85 and 90. However, it could be seen that Crystal 55 has the lowest temperature range than crystals of other grades.

Conclusion

The production of PVC compounds (crystals) has been successfully carried out, however, from the result obtained, it could be concluded that the quality of crystal (PVC compound) is a function of quantity of materials (chemicals) used. As the quantity of materials (chemicals) used increases, the quality of crystal is depreciating and the more the color changes as the temperatures increased.

The output of Crystal 55 is more than other grades because it is very soft, easily compressed that is to say; it has a low tensile strength. Furthermore, the output of Crystal 55 is more than other grades because the effect of heat would have burnt part of the products out put. The formulations have shown that Crystal 55 has the best quality product among others, and can last longer in cold weather, snow and hash weather.

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