Tribo Charging Powder Coatings

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Summary: At present tribo-guns have captured a fairly large market share of the electrostatic spraying equipment used in the powder coating industry for powder paint applications. However, powder paint system based on carboxyl functional polyesters and some special powder paint formulations cannot be sufficiently charged with tribo guns to obtain a good deposition efficiency of the powder on the object. Attempts have been made to solve this problem through addition of special additives to the powder coatings premix or to the ready-to-use powder. Additives of this type have been proven not to be ideal because they can have a catalytic activity and thus effect the powder coatings properties.
We developed oligomeric additives that enhance the tribo charging of carboxylic polyester resins based powder coatings, without influencing to the kinetics of the curing process and other properties of the coating.

Keywords: tribo charging, corona charging, powder coatings, carbocylic polyesters

Introduction

In 1960, the first electrostatic spray experiments were carried out allowing the application of powder paint to metallic objects. With this process is possible to apply films with a thickness from 40 – 300 μm, in one single coat. There are three powder-charging techniques: contact, corona, tribo and charging [1].

Contact charging

In this process, conductive powder particles are propelled through the gun. When the particles come into contact with the electrode, they acquire the same charge as the electrode. Contact charging is effective, however, the requirement that the powder particles have to be conductive. Most powder coatings materials available are non-conductive, consequently only corona and tribo technologies are used.

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Corona charging

Corona charging is the most widely used of the powder charging techniques. From physicists' point of view corona is a form of plasma. Plasma is ordinary matter in such an energetic state that its atoms have all their electrons stripped away. Normally, a plasma is associated with temperatures of thousands degrees, but in the case corona means a cold plasma, not by thermal energy, but by strong electric field. The basis corona charging principle illustrated in Fig.1 Powder is pumped through feed hoses to a spray gun. A charging electrode in the gun is connected to a high-voltage generator, the surrounding air is ionized and free ions are formed in the front of the charging electrode. When powder particles are transported through this ion-cloud, partial adhesion of these ions on the particles takes place and the powder particles become charged. The polarity of the charging electrode can be reversed to create either positive or a negative charge on the powder particles. A negative charge is generally preferred because ions can be generated in greater numbers withless arcing. Because no electrical field exists in areas surrounded by earthed metal due to electrostatic forces, no deposition of powder will take place in these areas. This effect is commonly known as the Faraday Cage Effect. After spraying the final results will be a thin film with insufficient decorative and protective properties.

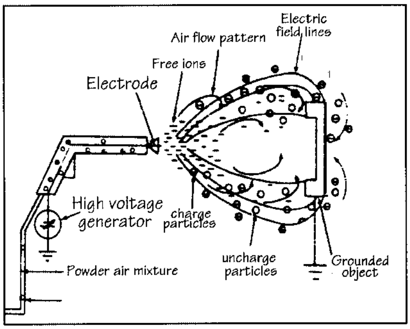


Fig.1. *Principle of corona charging*

The second phenomenon that occurs with Corona charging is back-ionization (Fig. 2).

Back-ionization is caused by an electrostatic field in the deposited powder layer on the surface of an earthed object. During Corona charging only 0.5% are charging powder particles. The rest of these free ions move, together with the charger powder paint particles to the object and are incorporated in the powder layer. As layer build-up increases, field strength increases and leads to ionization of the air in the powder layer. The positive ions move in the direction opposite to the oncoming negatively charged particles and ions. This results in neutralization of

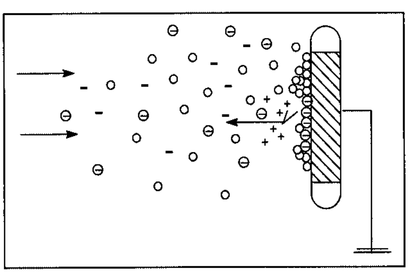


Fig. 2. *Back-ionization*

powder particles, limiting further deposition of powder, creating disturbances in the powder layer, which after curing can results in a coating with a poor apperance.

Tribo Charging

The tribo or frictional charging technique does not make use of a high voltage-generating source, therefore no electrical field is generated between the gun and the contact object. The powder particles are charged by frictional contact between the powder particles and the material, of the body gun. The relative electronegativity of materials commonly used in tribo-charged system is shown Table 1 [2]

Table 1. Relative electronegativity of commonly used materials

MATERIAL	RELATIVE ELECTRONEGATVITY
POLYURETHANE	least electonegative
EPOXY	↓
POLYAMID	
POLYESTER	
PVC	
POLYPROPYLENE	
POLYETHYLENE	
PTFE (teflon)	Most electronegative

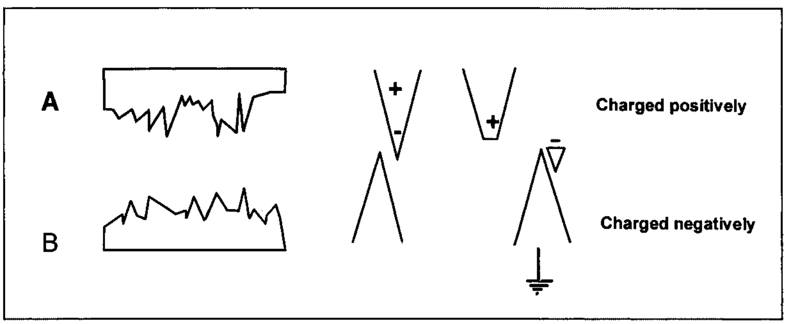


Fig. 3. *Mechanism of frictional charging*

The basic mechanism of tribo charging is illustrated in Fig.3. When the two materials A and B rub against each other little piece of material break off. If one of the materials is very electronegative and hard in comparison with the other material, as is the case for powder charging tribo system, the material transfer will cause a charge transfer. The application

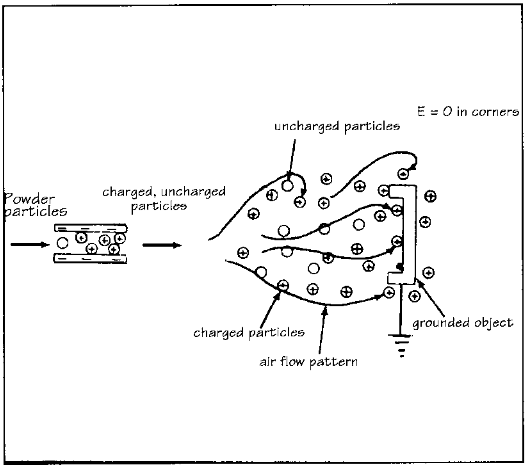


Fig. 4. *Principle of tribo charging*

process is illustrated in Fig. 4. A powder and air mixture enters a gun, where is passed through a tubular section. A conventional powder, such epoxy, polyester or hybrid, is passed through tube made of polytetra-fluoroethylene (PTFE, *Teflon*). As the powder particles collide with the walls of the tube, they pick up a positive charge by giving the electron to the tube, causing the tubes to become negatively charged. This negative charge is then passed to ground. Because is no external electric field in tribo applicators the movement of the particles from the gun to the object is primarily a results of aerodynamic forces. Thus little Faraday Cage-effect is generated, which is one of the greatest benefits that can attributed to tribo technology. Therefore this charging technique allows reach geometrically complex object to be powder homogeneously.

Due to the absence of free ions the Back-ionization does not occur for 10 to 20 seconds in tribo-charging system. Therefore it easier to obtain heavy or thick film with less porosity.

Stabiliation of generated positive charge

It should be noted that the tribo-charging could be improved if the powder is better suited to the stabilization of positive charge. The dielectric constant of PTFE (used in tribo guns as the frictional material) being very low (ε = 2.1), all substances with higher will get a positive charge when brought into intimate contact and separate from PTFE. However the systems used in powder coatings based on carboxy functional polyesters (ε = 3) have not been found to be appropriate for charge acceptance due to small differences in dielectric constant with Teflon [2].

There are several chemical structures that could accomplish of stabilization of positive charge on the powder paint particles. By analogy with what is used in xerographic toners, the addition of quaternary ammonium or phosphonium salts has been found to increase the

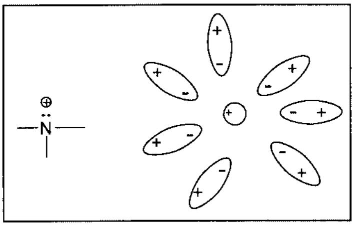


Fig. 5 *Stabilization of generated charge*

positive charging characteristic of the powder, improving transfer efficiency (Fig.5). Solution this type have been proven not to be ideal because they can also have a catalytic effect on the carboxy-epoxyreaction and thus have a negative influence on the flow appearance of the coating. Moreover, they a separated from the powder in the recycling process, as they differ from the specific weight, and thereby the powder loses its enhanced tribochargeability. Some other side effects of these compounds can be yellowing and poor corrosion resistant of the coating. To overcome these drawbacks, work is now in progress to find additives which enhances the tribocharging of polyester resins and subsequently of powder formulation of these without making concessions to the powder paint formulation. [3,4]

Research and development

Inorganic external additives [5]

Addition of the colloidal SiO_2 and Al_2O_3 due to their specific surface was used to improve the charging characteristic. The additive is incorporated into the powder coatings compositions by simply blending it in. The optimum levels are from 0.1 – 0.2% by weight. One of the great advantages of this invention is that permits much more precise adjustment of the tribo charging characteristics than would be possible with a "factory packaged" powder.

Nitrogen containing compounds as tribocharging additives [6]

As an electric charge-increasing agent of hybrid powders the following compounds were used:

- blocked isocynate
- guanamine
- benzotriazole
- anilid of the oxalic acid

Table 2 shows the example of the composition. The chargeability of this system is 2.8 μA[1]

[1] In order to obtain a proper triboelectric process, chargeability up to at least 2 μA will be necessary.

Table 2.

Component	weight parts
Esters Resin ER 8600*	90
Epikote 828 (Shell)	10
Adduct B 1530**	2
Modaflow (Monsanto)	0.7
Curezol C 172	0.3

* -Polyester resin M=3000, Acid number = 36
** -IPDI blocked with caprolactam

Azine and quaternary salts as tribocharging additives [7]

The following compounds enhanced tribo-chargeability without influence on the powder coating properties were described:

- triarylmetane derivatives
- azine derivatives
- tiaazine derivatives
- quaternary salts: e.g. $[PhCH_2N^+Bu_3]$ $[HO\text{-}C_{10}H_2SO_3^-]$

The additives are mixed with other components of powder system an extruded. In Table 3 is an example of formulation. The chargeability of this system is 2,1µA.[2]

Table 3.

Component	weight parts
Alfatalt AN 721 (Hoechst)	399
Becopox EP 303 (Hoechst)	171
Kronos 2160 (TiO_2) (Kronos Titan)	295
Blanc Fixe F/$BaSO_4$ (Sachteleben Chemie)	100
Additol XL 496 (Hoechst)	30
Benzoin	5
C.I. Solvent Blue 124 (tribo agent)	0.5

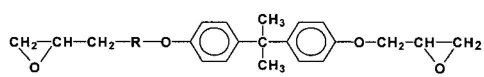
[2] The chargability without tribo agent C.I. Solvent Blue 124 is 0.9 - 1.2 µA

Sterically hindered tertiary amine and amninoalcohol as tribocharging additives[8]

The use of nitrogen containing compounds can have a positive effect on the tribo-charging of powder paint, but also decreases the stability of powder coatings because of an undesired catalytic activity on the epoxy-carboxy reaction. Attempts have been made to solve this problem through addition sterically hindered tertiary amine or aminoalcohol is added during the preparation of polyester. An aminoalcohol containing two hydroxyl group copoly-merizes with polyester and, as results, diffusion of the additive from the coating is avoided. As additive the following compounds were used: N,N-diisobutyl-3-amino-2,4-dimethylpentane (1), N,N-dimethyl-3-amino-2,4-dimethylpentane(2), diisopropyloethanolo-amine, dimethylo-neopentanoloamine (3). The optimum levels of the additives are from 0.5 – 1% by weight. The chargeability are from 3.0-3.6 μA and the additives do not have an influence on other coating properties.

Oligomeric sterically hindered tertiary amine as tribocharging additive (ICRI invention) [9]

As tribocharging additive oligomeric sterically hindered tertiary amine modified with isophorone disocyanate (IPDI) was obtained.



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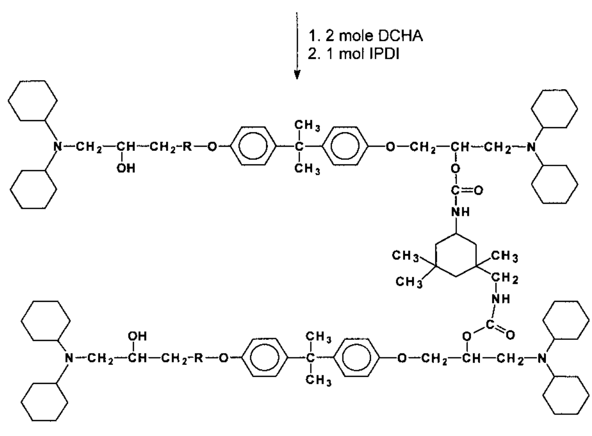

ELTRIBO

The additive (*Eltribo*) can be added to the cooling resin after synthesis, in the extruder, during the powder coating production process. The amount of Eltribo additive is 1-3% (wt) calculated on the carboxylic polyester resin. It enhanced tribochargeability to 2.5 mA without a negative influence on the coating properties. The example of the formulation is shown in Table 4.

Table 4.

Component	weight parts
Polyester resin *	38
Epidian 012 (ZCh Sarzyna)	23
TiO_2	40
Resiflow PV5 (Worlee)	0.7
Benzoin	0.5
Eltribo	3

URALAC 2450 or POLICEN 1100 (Polifarb Cieszyn-Wrocław S.A.), Acid Value 36 – 38

Summary

At present Tribo-charging technique have captured a fairly large market share of the electrostatic spraying equipment used in the powder coating industry for powder coating applications. The Tribo technique has certain advantages over the Corona technique such as the ability to create a fairly homogeneous powder layer on geometrically complex objects. This is due to the absence of a strong Faraday Cage-effect that occurs with the Corona Charging technique. However, the powder paint systems based on carboxy functional polyester cannot be sufficiently charged with tribo guns to obtain a good deposition efficiency of the powder on the object. Amines and organic salts enhance tribochargeability, however, these compounds also have an negative influence on other coating properties due to a catalytic effect on the carboxy-epoxy reaction. Some other side effects of these compounds can be yellowing and poor corrosion resistance of coating. This problem can be solve by using hindered tertiary amine or aminoalcohol as tribo additive or by modification of saturated polyester resins.

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