Vincentz Network GmbH & Co KG
Emmanouil Spyrou

Powder Coatings
Chemistry and Technology
3rd Revised Edition
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Chemistry and Technology

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Preface

“If I have seen a little further, it is by standing on the shoulders of giants.” (Isaac Newton, 1676) The excellent original book “Powder Coatings, Chemistry and Technology” written by Tosko Aleksandar Misev and later updated by Peter Gillis de Lange has served for my generation as a sort of bible on its sector. Therefore, it has been a great honor while at the same time a tremendous challenge to write a third edition of this book. Due to this respect the original text is maintained where possible, but altered and extended if recent scientific findings made it necessary.

The Stone Age did not end due to a lack of stones. New technologies replace the old ones; novel developments change the look of the world, sometimes at an incredibly fast speed. Just to name a few recent incidents since the last print of the book: The rise of China, severe worldwide financial crises, the changed way of communicating (e.g. smart phones, social media) and radical governmental regulations (e.g. REACH). Of course, these developments had influences on the world of powder coatings, too. Consolidation, relocation and customization are some of the effects. Replacement of toxic ingredients (e.g. TGIC), use of energy saving curing methods and the extension of powder coatings into new application fields are the interconnected technological changes that are covered in this book.

This book is directed to anybody who is involved in developing, producing, testing and marketing of powder coatings, raw materials or application equipment.

What is new compared to the second edition? More than 5,000 recent articles and patents concerning powder coatings have been evaluated and 250 of those have been referenced in this book to ensure that it illustrates the current state-of-the-art. Highlighted core terms and a significant extended index should help finding the desired topic in a shorter time. A list of powder coating related web addresses will enable the reader to locate additional relevant information at the push of a button. Product and company names have been updated as much as possible. Plus more than 30 new photos, diagrams and drawings complete this revised and updated third edition.

I would like to thank Werner Grenda for valuable discussions, Dr. Corey King for corrections of the manuscript and Dr. Michael Ringel for his contribution regarding REACH. Many thanks to the two dozens companies for the excellent additional photos they provided for the 3rd edition of this book.

Emmanouil Spyrou

Marl, Germany, Mai 2012
Another interesting book hint...

Coatings Formulation
2nd Revised Edition

The 2nd revised edition of the book “Coatings Formulation” provides detailed explanations of new recipes and paint formulations in two steps: From the chemical composition of the binders to the formulation advice and analysis of existing recipes. As a special plus the reader will find new figures and tables to understand the development of the paint formulations and to visualize the multiplicity of the processes much better.

Order at: www.european-coatings.com/shop
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1 Introduction

1.1 Historical background

Two thousand five hundred years ago the great Greek philosopher Thales of Miletus (624 to 556 BC), who was dubbed as the “father of science”, was the first to discover that amber stone when rubbed attract other objects. The Greek word for amber, ἀμβρός (electron), is the origin of electrostatic forces, which are used nowadays for almost 90% of all powder coating applications.

The appearance of powder coatings is often associated with the ecological and energy related events of the late 1960’s and early 1970’s. The famous Rule 66 which was brought in by The Town Council of Los Angeles in 1966 was the first legislative act regulating the environmental aspects of the coatings. Later on similar regulations were introduced in most of the industrially developed countries.

Although the history of powder coatings has been strongly influenced by environmental aspects, first developments in the field began in the 1940’s with a simple flame spray application process. Early in 1950’s powdered PVC was successfully applied by Gemmer in a fluidized bed process on a preheated metal surface [1]. A patent application for Gemmer’s invention was filed in Germany in 1953 and the patent was issued in 1955. Very soon the fluidized bed technique for application of thermoplastic powders including polyethylene and nylon powder coatings was well established in the USA.

In the late 1950’s the first thermosetting powder coatings appeared on the market, mainly as a result of the research work done by Shell Chemicals. The target was development of superior protective (“functional”) organic coatings for the company’s own underground natural gas and oil pipelines. The first systems were relatively simple physical dry blends of epoxy resins, hardeners and pigments dispersed by ball milling techniques. Due to a considerable degree of heterogeneity, the application results were rather inconsistent.

The hot melt mixing methods of the present day for production of powder coatings were preceded by a technique that employed liquid epoxy resins and hardeners. The homogeneous liquid binder/crosslinker blend was prereacted until partially cured (“B stage”) solid material was obtained, which was finely ground in the next step. The completely cured “C stage” was obtained by stoving the “B stage” powders at high temperatures. A drawback of this technique was the lack of reproducibility and difficult control of the process [2].

Hot melt compounding on a heated twin roller mill or in a heated Z-blade mixer was already a step forward in the development of thermosetting powder coatings, but the immense cleaning problems, created by the fast(er) curing powder coatings, have almost completely excluded the Z-blade mixer and of course the twin roller mill from the machines (extruders) used to produce contemporary powder coatings. However, Z-blade mixers are still used for batch-wise production of thermoplastic powder coatings, where chemical reactivity does not play a role.

Extrusion methods for production of thermosetting powder coatings, which are in current use, were developed in the Shell Chemical Laboratories in England and The Netherlands in