RESEARCH REGARDING THE ADHESIVE WITH VERY LOW EMISSIONS OF VOLATILE ORGANIC COMPOUNDS

IONIŢĂ IRINA, CIOBANU DOMNICA, TULBURE MONICA

University of Bacau, Mărăşeşti Stret, no. 157, cod 600115
University of Iaşi, str, D. Mangeron no. 67, cod 700050

ABSTRACT: The floor covering adhesives have been deeply modified during the years. The first major development was the formulation of polymer-based products in aqueous dispersion as an alternative to organic solvents. To minimize both indoor and outdoor pollution, Mapei went further on formulating solvent-free adhesives with very low potential emissions even in the long term. Developing these adhesives required the parallel development of methods for monitoring and analyzing the formulations' emissions over time. A laboratory "environmental test chamber" was built for the purpose. Adhesive is placed on glass plates that are inserted into the test chamber. A stream of air is forced through the chamber and all the volatile organic compounds are collected and analyzed by means of gas-mass chromatography. A thorough analysis of the large quantity of results made it possible to establish a bi-logarithmic correlation of emissions vs. time from which the overall emission behavior from the 24-, 48- and 240-hours measurements can be predicted in sufficient approximation.

KEYWORDS: adhesive, emissions, organic compounds, polymers, solvents, monitoring methods.

1. INTRODUCTION

The initial use of organic products as auxiliary materials in the building industry is lost in the mists of time. Yet, from an historic perspective, the most enduring example is certainly when the ancient masons started to mix straw [cellulose] with clay for the preparation of bricks and walls. These products are the ancestors of modern asbestos-based (nowadays synthetic-fiber-based fiber reinforced cements).

Even the ancient Romans showed interest in building products modified with organic ingredients. Their use of sulfated animal blood as air entraining agent for "cements" used in their road construction program has been reported.

Only in recent times, in the second half of the 50s, after the development of synthetic polymers, organic products were widely used in the building industry both inside cement and other construction materials to enhance performance and workability, and on cement, in the form of sealants, water-proof, protective paints, adhesives and consolidating compounds. Ail of these formulations are based on non-volatile, intrinsically non-polluting polymers and copolymers (polyacrylates, polyvinyl esters, polystyrene-butadiene, polyurethane, epoxy, silicon, polychloroprene etc.), which contribute to indoor pollution only because they always contain some amounts of other low-molecular-weight, high-vapor-pressure products.

2. MATERIALS AND METHODS

Experiments performed in research laboratories and in the field have shown that even small amounts of chemical products with moderate to high volatility can generate substantial emissions that can linger for months at measurable levels in the air in interiors, depending on the conditions in which they were applied and the ventilation in the area (Fig. no.1.). The detriment to the end-user's health and comfort naturally depends on the toxicological and organoleptic properties of each substance, but the risk is generally rather low.

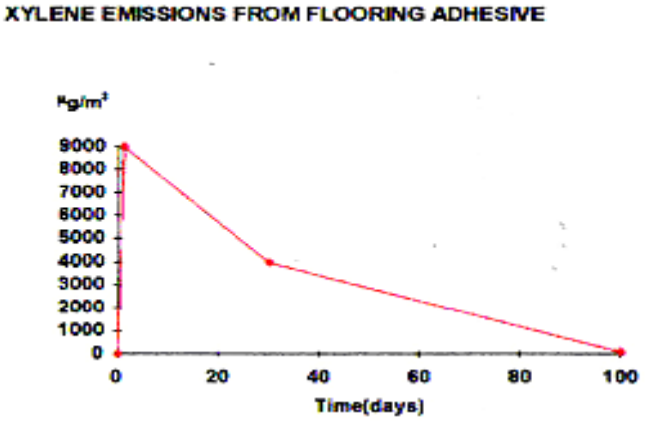

Fig. 1 Decay curve of indoor pollution from a floor installed with a solvent –borne adhesive

Developing these adhesives required the parallel development of methods for monitoring and analyzing the formulations' emissions over time. An "environmental test chamber" was built in the laboratory for the purpose with a volume of 35O liters. Adhesive is placed on glass plates that are inserted into the test chamber.

The ratio of the surface measurement of the adhesive applied on the glass to the volume of the chamber (0.4 m^2/m^3) simulates a situation that might exist in a room in a typical apartment. A stream of air is forced through the chamber which is purged of volatile organic compounds in four stages through a complicated filtration and purification system programmed to provide a total change of air every two hours. Leaving the chamber, the air passes through tubes that contain absorbent material. The volatile organic compounds collected are analyzed at established intervals by means of thermal desorption of the tubes and the injection of vapor into a chromatograph that is connected to a specially calibrated mass spectrograph. In the initial phase of our study the emissions were monitored for ten consecutive days. This caused long delays between tests and slowed the pace of the research, making it impossible to evaluate more than two or three formulas per month.

A more thorough analysis of the large quantity of ten-day test results made it possible to establish a bi-logarithmic correlation of emissions vs. time.

From this, an algorithm was calculated that could mathematically predict in close approximation residual emissions at 10 days based on 24-hour and 48-hour test data.

3. RESULTS AND DISCUSIONS

Solvents, the most widely used volatile organic components in this field, remain by far the ingredients among all the others, which mostly contribute to the environmental pollution.

The first major development was therefore the formulation of polymer-based products in aqueous dispersion as an alternative to organic solvents.

This made it possible to reduce drastically the total emissions of volatile organic compounds (VOC). These substances evaporate immediately after adhesives are applied and in the first few hours after flooring is installed (carpet, wood parquet, rubber, etc.). This was a great benefit for the health of professional installers, who were no longer exposed to harmful fumes, and also for the environment. This was a significant achievement.
Stimulated by market demand, by increasingly strict international standards and the self-regulatory codes of associations of adhesive and floor covering manufacturers, Mapei directed its research efforts in two different streams: the first, formulating solvent-free adhesives with very low potential emissions even in the long term, and the second, designing analytical systems to monitor VOC emissions over time in the laboratory. These systems would both guide the research and enable various products on the market to be objectively evaluated.

Developing formulations for indoor applications required careful selection of ingredients with very low VOC emissions both in the short and the long term. The ingredients for the adhesives included: binders (usually polymers); initial tackifying agents (resinous products); regulators of viscosity; plasticizers or, alternately, substances that add flexibility » additives (wetting agents, dispersing agents, biocides).

This selection was made possible only with the close cooperation of those raw material manufacturers who were more sensitive to environmental concerns. Was chose binders that were synthetic resins in aqueous dispersion with very low amounts of free monomers or volatile oligomers.

These polymers are manufactured in Northern Europe and North America. Some are manufactured by Mapei itself. The polymers used could not contain even traces of known carcinogens, mutagens, or teratogens, nor free monomers in amounts larger then 0.1%. This choice was neither easy nor banal because at present few polymer dispersions on the market meet these conditions. The same thing could be said for the other macromolecular materials as well, such as the resinous tackifiers. Eliminating solvents as thinners to regulate viscosity and replacing them with water necessitated the inclusion of wetting agents or dispersing agents as additives to facilitate the compatibility of the various ingredients (water, mineral fillers, plasticizing oils, etc.) and also biocides as preservatives. Although present in small amounts, even these ingredients were chosen with the utmost care as to potential emissions, especially the biocides selected, which contain no substances that release formaldehyde or other volatile products over time.

As for plasticizers and substances that add flexibility, was opted for oils or resins with high molecular weight and very low vapor pressure.

4. CONCLUSIONS

A more thorough analysis of the large quantity of ten-day test results made it possible to establish a bi-logarithmic correlation of emissions vs. time (see Figure no. 2).

From this, an algorithm was calculated that could mathematically predict in close approximation residual emissions at 10 days based on 24-hour and 48-hour test data.

Once the formulas of our "very low VOC" product line were perfected, we had to make sure no contamination occurred during the production process. Production lines were reserved exclusively for these products to prevent pumps, valves and pipes used in "non-eco" processes from leaving traces of VOC that could alter the properties of the finished product.

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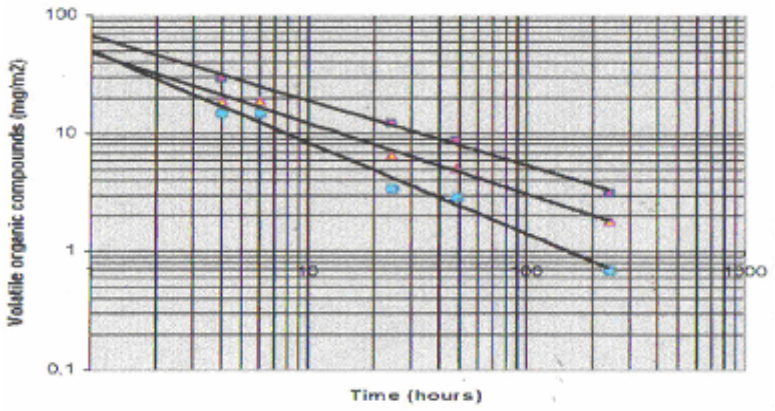

Fig. 2 The VOC emissions vs. time correlation

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