DEVELOPMENT OF ELECTRON BEAM CURING TECHNOLOGY OF HIGHLY PIGMENTED COATINGS FOR WOOD FINISHING.

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INTRODUCTION

The expanding worldwide concern about environmental protection and the effects of releasing volatile organic compounds (VOC's) into the atmosphere is creating an increasing interest of the utility and benefits of radiation curing of inks, varnishes and coatings.(1) Ultraviolet and Electron Beam curing are known as a clear technology once they employ 100% solid chemicals and are for this reason used to replace polluting technologies.

The furniture industry, one of the largest consumers of low-solids, solvent-based coatings, needs consequently to reduce solvent emissions; in this case, radiation curing is one of the indicated technologies.(2)

Low-energy electron beam and UV light combination is used to cure fillers and clear varnishes or highly pigmented coatings applied to particle board, hardboard or medium-density fiberboard (MDF). Coated products are used for furniture, doors and cabinets.

The Nuclear Energy Research Institute, IPEN-CNEN/SP and Sayerlack Brazilian Industry of Varnishes, have been working together since 1990, to develop the electron beam curing technology for wood derivate finishing. Highly pigmented such as white, black, brown and gray acrylated based coatings have been developed and studied.

This paper describes the irradiation conditions of the process and the dose distribution in function of the coating thickness. The influence of dose on the end properties of the cured samples is presented. The performance of the high gloss coated cured samples obtained by this process under physical, mechanical and chemical tests, is discussed.

EXPERIMENTAL

During this research development were studied three different substrates: particle board (for paint use),medium-density fiberboard (MDF), both from several manufacturers and hardboard from Duratex S.A of Brazil.

The filler used was the bright UV Sel and as EB coating, the bright white of EB Lack line ,manufactured by Sayerlack Brazilian Industry of Varnishes.

FILLER AND COATINGS APPLICATIONS

a)MDF Substrate

On MDF substrate, two layers of UV Sel filler resulting a 40 g/m2 total layer were applied . This filler was applied wet over wet, with a sparer, and cured with a 200 watt/inch UV lamp.

An electronic sander machine, with abrasive papers number 280 and 320, was used to finish the UV cured samples.

The pigmented bright coating was applied with a curtain coater and the coating layer ranged from 120 g/m² to 180 g/m², depending on the finished product quality aimed. Thicker layers present better finished surface but layer upper to 200 g/m² presented problems in the cold check.

ELECTRON BEAM IRRADIATION PROCESS

The irradiation assays were carried out at IPEN facility, where there is a 1,5 MeV and 25 mA Dynamitron II electron beam machine, manufactured by Radiation Dynamics Inc.. This electron beam machine is not indeed for coating applications.

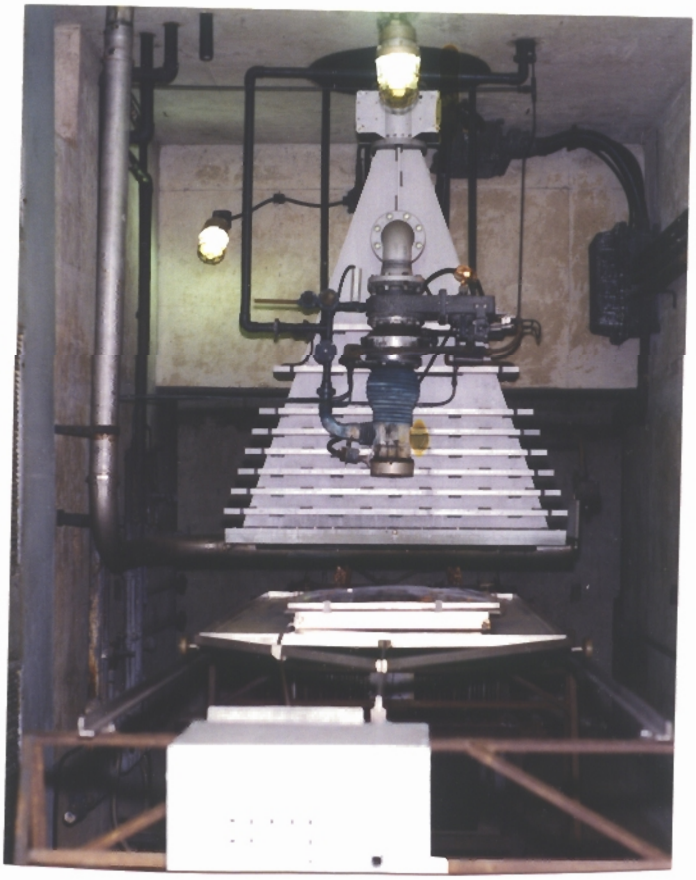

Fig.1 Aluminium irradiation display

The radiation curing of inks and varnishes uses low-energy electron beam machine, with energy up to 300 keV.

Samples were irradiated in a specially projected aluminium display showed in figure 1 under Nitrogen atmosphere. The flux of Nitrogen gas used was 2 l/min. Samples were irradiated in the following conditions:
E=0,630 MeV, I=7,2mA , v=3,36 m/min ,dose rate = 30 kGy/pas.

This high energy value is not adequate for this application but it is the lowest possible value for high value of current. Due this reason, the radiation reaches a part of the thickness of the substrate, as is shown in fig 2. This problem is avoided when a low-energy electron beam machine is used.

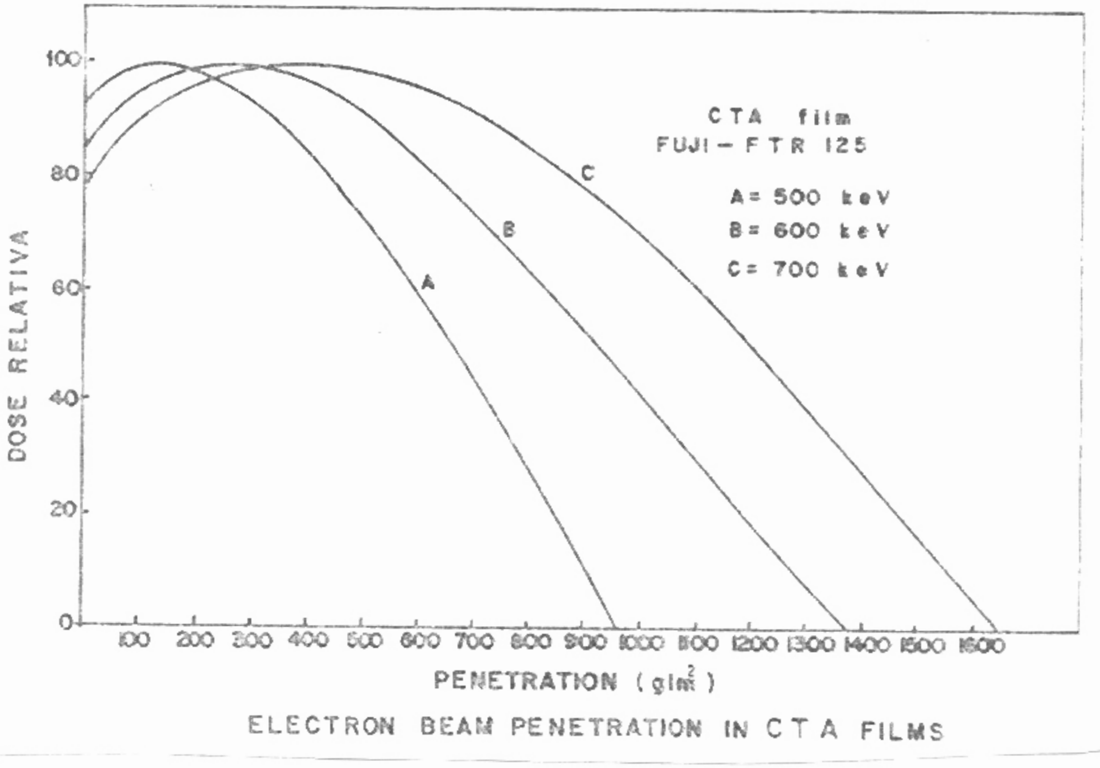

Fig.2 - Dose distribution in CTA films

These selected conditions permitted a better versatility to change the dose rate.

The sensibility of the ink studied in relation to the oxygen concentration present in the irradiation atmosphere, depends on the formulation and the curing speed.

In this process, the irradiation speed used was very low and for this reason the sensibility to the oxygen is not very high. However, when the nitrogen flux used was lower than 2 l/min, the cure of the samples was not completed. This can be checked by using a scratch test applied immediately after the curing process. Besides that, a higher oxygen concentration in the irradiation chamber diminishes the gloss of the cured coatings. In an industrial process scale it is possible to control the gloss of the sample surface ranging the oxygen concentration in the irradiation atmosphere .

The 30 kGy dose value was the most recommended for the formulations tested.

b)Particle Board and Hardboard Substrates

The filler and coating application conditions and the irradiation process employed for the particle board and hardboard substrates were the same used to the medium - density fiberboard (MDF). The filler quantity applied was the only difference .To obtain good coatings, particle board requires at least 80 g/m² layer while hardboard substrate just requires a 20 g/m² layer.

RESULTS AND CONCLUSION

Samples cured with a 30 kGy electron beam dose were submitted to a series of physical and chemical tests (3) and the results obtained are herein discussed.

a) Resistance to household materials and chemical products. NEMA-LDI-2.05

Samples of coatings cured with 30 kGy dose have been put in contact with some chemical solvents and household materials and the results, observed after 16 hours , are shown on table 1.

Products	non covered	covered	contact
distilled water	1	1	1
olive oil	1	1	1
mustard	1	1	1
ketchup	1	1	1
mercurochrome	1	1	1
coffee	1	1	1
iodine (1%)	1	2	3
gasoline	1	1	1
acetone	1	1	1
ethyl alcohol	1	1	1
domestic powder soap (5%)	1	1	1
vinegar	1	1	1

Tab.1- Chemical resistance of cured samples.

where:

uncovered: cotton fabric moisted with the substance and put on the cured samples.

covered: cotton fabric moisted with the substance and put on the cured samples but covered with a glass dish.

contact: cotton fabric moisted with the substance and put on the cured samples and pressed.

level 1: non attacked
level 2: slightly attacked
level 3: attacked

The results show that only the 1% iodine solution attacks the EB cured samples.

b) Pencil hardness and Scratch Hardness. ASTM D-3363

Scratch Hardness 3H
Pencil Hardness 2H

These results show the cured samples can be used by furniture industry.

c) Cold Check. ASTM D-1211

The objective of this test is to determine the resistance to deformation and elongation of an ink applied on wood and derivates, when submitted to severe temperature variations.

1 cycle: The tested sample is placed in a freezer at -18°C for 1 hour. After this time the sample is withdrawed and immediately placed in an oven at 60° C for 1 hour. Then, the sample is left at room temperature for 15 minutes. This cycle is repeated until the moment cracks come out and are visualy detected or until the conclusion of a specified number of cycles.

All 30 kGy formulations cured with a coating layer lower than 200 g/m^2 resisted very well up to 50 cycles. However, samples with coating layer higher than 200 g/m^2 presented cracks after 17 cycles. This problem can be solved by carrying out some modifications in the formulations to improve the ink flexibility.

d) Adhesion. ASTM D- 3359

All tested samples from different wood substrates were approved in the adhesion test.

CONCLUSION

Eventhoug this research used a laboratory scale irradiation system and it was not possible to set up an experimental paint line under clean atmosphere, it permitted to carry out a detailed study of the behavior of the tested formulations . These products are ready to be applied in an industrial line.

The aimed quality of the end products will determine the kind of substrate to be choosen as well the filler and coating layers that may be applied.

Once this radiation cure process has been well studied, it can now be offered to the furniture industry in order to replace a conventional pollutent curing technology.

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