INFLUENCE OF THE COMPOSITION OF POLYVINYL CHLORIDE – PLASTISOLS – COMPONENTS ON THE PROPERTIES OF STRUCTURED WALLPAPERS

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Received August 27, 2008

The large diversity of utility wallpapers provided on local and world markets is considerable, determining an increased demand and enhancing both quality and aesthetic claims.
A thorough research on the composition of some basic components of polyvinyl chloride (PVC) pastes (plastisols)[1] is a prerequisite for assuring a high quality production, optimal optic features (whiteness, opacity, gloss), suitable viscosity and behavior at foaming, foam structure homogeneity, thermal and mechanical stability at layering, and perfect adhesion.
The present paper investigates the influence of some basic components of PVC pastes on coating whiteness, opacity and viscosity. Three types of paper have been used. The recipes for the PVC pastes used in the preparation of various structured wallpapers have been formulated and particularized under laboratory conditions.
The results obtained show that:
- PVC paste viscosity depends on the coarseness of the PVC component particles, seen as diminishing with their increase, as a result of lower dispersion, lower stability and lower uniformity.
- Time-stability of the PVC paste viscosity depends on particle coarseness and plasticizer's molecular mass and gelatinizing ability. The average values of the molecular mass and of the final gelatinizing ability of the plasticizer give PVC pastes with minimal viscosity deterioration in time.

Keywords: PVC paste, wallpaper, viscosity, whiteness, mattness degree

INTRODUCTION

The considerable diversity of utility wallpapers provided on local and world markets, along with the introduction of new assortments, determine an increased demand and enhance the quality and aesthetic claims. Consequently, research on the chlorine covering of the basic components is a highly interesting problem, offering various future developments.

Wallpapers are decorative wall covers, used for facing the walls of administrative buildings, residential, public and industrial premises. An aesthetically attractive aspect, combined with effective exploitation, long lastingness and preservation against different aggressive media during their lifetime are their basic functions.[2] This is achieved by the application of diverse colors, paintings, reliefs, decorations, as well as by uniformity requirements along the whole production process.[3,4] As a function of their particular applications, they should possess high quality surface coating (strength, light-, hydro- and thermal resistance, uniform ornaments, qualitative polygraphic treatment, invariability during the production process and others). Consequently, a thorough research on the composition of some basic components of polyvinyl chloride pastes is a prerequisite for a high-quality production of coverings, ensuring optimal optic features (whiteness, opacity, gloss), suitable viscosity and behavior at foaming, foam structure homogeneity, thermal and mechanical stability at layering and perfect adhesion.

Wallpaper PVC pastes were first produced in Germany, in 1931, by emulsion hydrolysis of vinyl chlorine, to which agglomerates of 5-70 micron particles of vinyl chlorine were added. PVC pastes are defined as dispersing agents of either homo- or joint polymers of vinyl chloride with molecular masses of nonvolatile plasticizers[5] between 150,000 and 180,000. The composition varies depending on the utility purpose and on the required quality of the end product, the basic components of the PVC pastes being as follows: powdered PVC, plasticizer, secondary plasticizer, thermo-stabilizer, light stabilizer, filler (optical whitener, viscosity regulator, UV-absorbent, matting agent). The quality of the PVC pastes depends mainly on the type and quantity of polyvinyl chloride, on the filler, porphyry and stabilizer.[6] The PVC dispersions are spread over suitable bases, a foamed layer thus resulting from the thermal treatment, which leads to a flexible PVC layer, a process known as gelatinization.

Polyvinyl chloride wallpapers are wall coverings produced on either paper or synthetic carriers. As a paper base, normal wallpaper or special types of paper for offset, deep and flexography printing, weighing between 60 and 200 g/m^2, including bleached or unbleached pulp in their composition, are usually used. Normally, the polyester materials or the PVC films are synthetic bases.

EXPERIMENTAL

The influence of the composition of some basic components of PVC pastes on coating whiteness, opacity and viscosity is investigated.

Three types of paper – two one-layer wallpapers, weighing 100 and 105 g/m^2, respectively, and a two-layer paper, weighing 120 g/m^2 – and a polyester material containing 60% cellulose, 20% polyester and 20% latex, with a 60 g/m^2 mass, have been used as carriers.

Suitable recipes are provided for the production of different types of PVC structured wallpapers for the preparation of PVC pastes under laboratory conditions (Tables 1A and 1B).

PVC paste preparation involves the mixing of plasticizers, stabilizers and viscosity regulators, followed by the subsequent addition of fillers and pigments. The mixture is well blended and homogenized through stirring. The PVC dispersion is added, followed by mixing for 8-10 min, until a fine blending, spread over the carriers, is obtained (foaming conditions: temperature – 200 ºC, time – 45 sec).

After thorough paste homogenization, a part of it was separated for viscosity measurements – C_p, while the other part was spread over the paper bases. The following indices have been determined on the thus obtained test samples:

> whiteness level – %

> yellowness level – %

> opacity – degrees.

PVC paste viscosity measurements were performed under laboratory conditions, on a Brookfield DW-1 type viscosimeter. The obtained results, multiplied by 1000, give the viscosity in Sp. The ageing of PVC pastes was assessed by viscosity measurements after 1, 24 and 48 hours.

The whiteness level was measured under laboratory conditions, on an Elrepho-2000 device, the mean value of three measurements being accepted as %.

Opacity was determined on a DR UMEA4 LANGE apparatus.

RESULTS AND DISCUSSION

Viscosity

The results on viscosity, illustrated in Figures 1 to 11, show that the viscosity of the PVC pastes is influenced by the particle size, type and quantity of residual emulsifier. At high coarseness levels of the polyvinyl chloride particles and significant amounts of residual emulsifier, PVC pastes viscosity is low, as due to the prevention of polyvinyl chloride particle swelling, caused by the plasticizer. The amount of applied plasticizer depends on the PVC grade viscosity attained. White spirit or other viscosity regulators are used for further viscosity regulation.

Relying on the plotted graphics and observing the ageing of PVC pastes, it may be noted that the viscosity values of different recipes are quite similar. All pastes show a pseudo-plastic liquid behavior, which is fully expected and logical, complying with the requirements on paste colloid stability. Viscosity enhancement in time is observed in all recipes, the highest values being attained for recipes 3 and 10, while the lowest are recorded for recipes 1, 6 and 8.

Hence, the last three recipes are characterized by the highest lastingness values, because of the presence of a PVC-component with the smallest particles and of a plasticizer with a low molecular mass. Composition 11 has the lowest initial viscosity, as it includes a higher amount of high molecular mass plasticizer with a low gelatinizing ability.

The plasticizer type influences the ageing of PVC pastes. The lower the gelatinizing ability and the higher the molecular mass, the higher the values of the paste ageing are. Average values of molecular mass and plasticizer's gelatinizing ability give PVC pastes with minimum viscosity deterioration in time (Figs. 7 to 9).

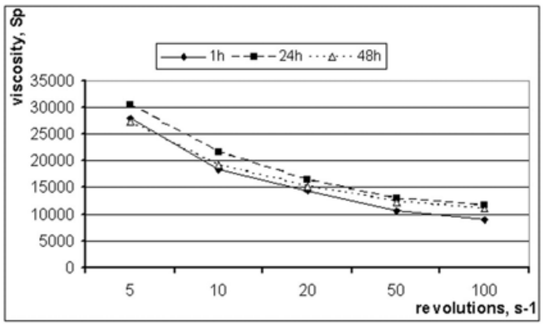

Figure 1: Graphic dependence of viscosity on revolutions for recipe 1 (Table 1A)

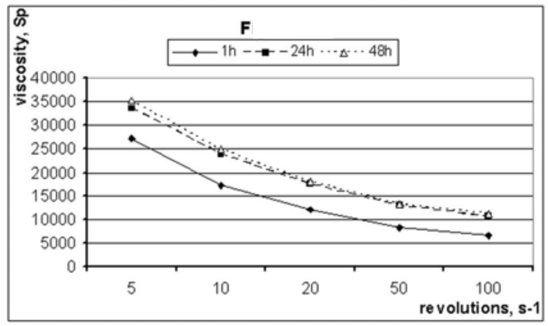

Figure 2: Graphic dependence of viscosity on revolutions for recipe 2 (Table 1A)

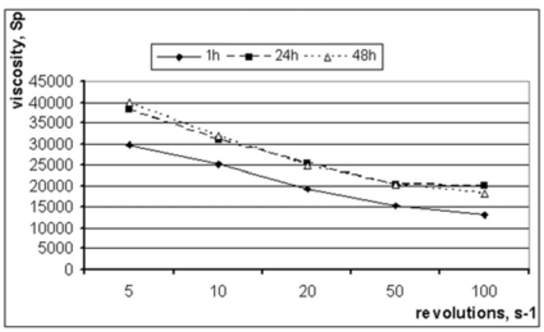

Figure 3: Graphic dependence of viscosity on revolutions for recipe 3 (Table 1A)

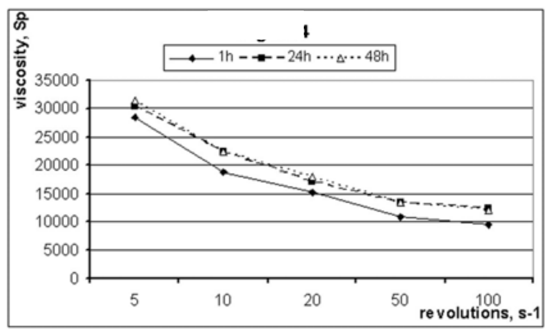

Figure 4: Graphic dependence of viscosity on revolutions for recipe 4 (Table 1A)

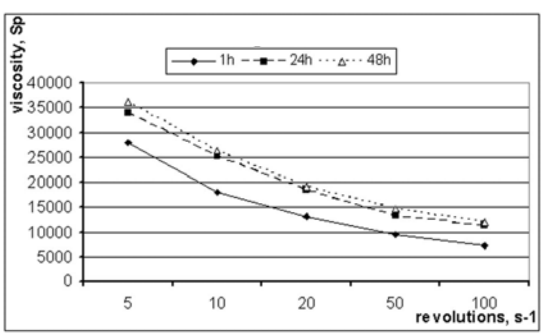

Figure 5: Graphic dependence of viscosity on revolutions for recipe 5 (Table 1A)

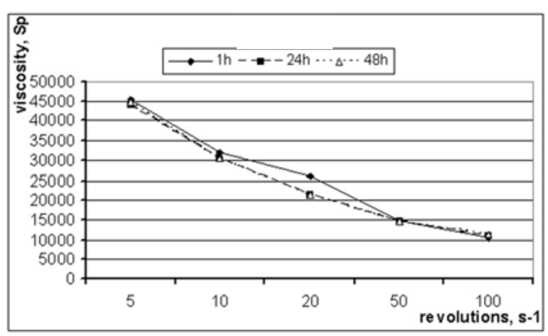

Figure 6: Graphic dependence of viscosity on revolutions for recipe 6 (Table 1B)

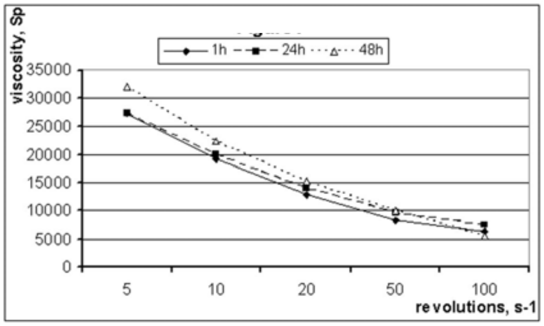

Figure 7: Graphic dependence of viscosity on revolutions for recipe 7 (Table 1B)

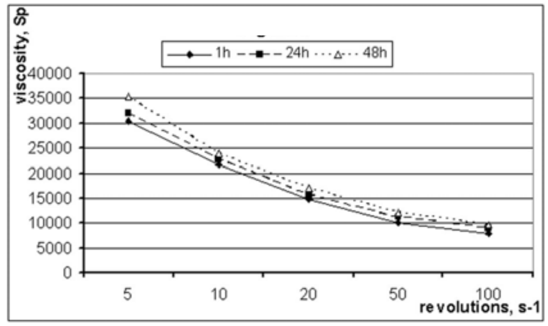

Figure 8: Graphic dependence of viscosity revolutions for recipe 8 (Table 1B)

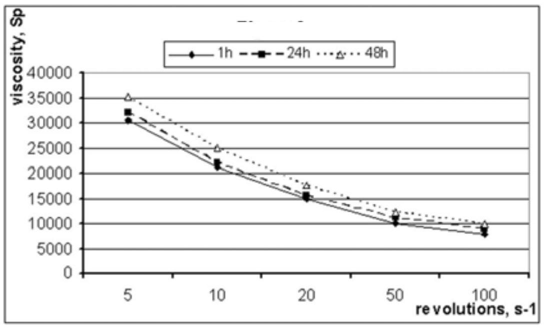

Figure 9: Graphic dependence of viscosity on revolutions for recipe 9 (Table 1B)

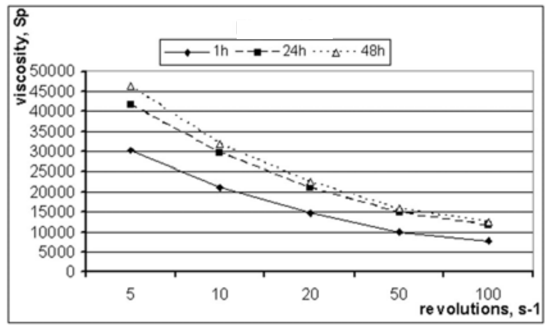

Figure 10: Graphic dependence of viscosity on revolutions for recipe 10 (Table 1B)

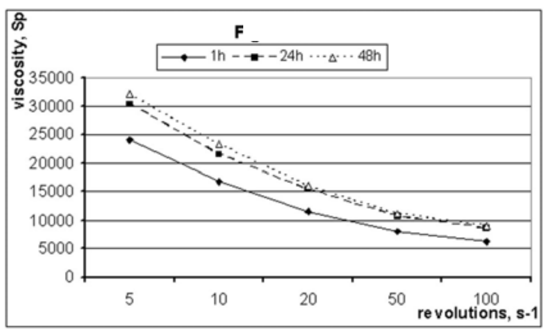

Figure 11: Graphic dependence of viscosity on revolutions for recipe 11 (Table 1B)

Optical properties

The values obtained for the (white and blue) trial samples of compact PVC pastes are listed in Tables 2A and 2B, according to the recipes in Tables 1A and 1B.

Tables 2A and 2B show that the best optical characteristics are to be observed in PVC pastes obtained according to recipes 1 and 4, as due to the presence of PVC paste E68SA, a PVC-component with the coarsest particles. Composition 4, requiring an increased filler quantity, is intensely white in color. An increased filler quantity leads to a proportional enhancement in whiteness, but only if the amount of white pigment is not reduced and the paste is not diluted with a solvent. The amount of white pigment does not affect whiteness, this characteristic being affected only by the filler content. The higher the amount of titanium dioxide is, the whiter the coverings are, because it is the very high whiteness and fineness of the particles that determine a higher optical uniformity of the PVC pastes and, consequently, a higher whiteness. The exchange of 40% TiO_2 with calcium carbonate, characterized by lower whiteness and higher particle size, causes insignificant whiteness diminution, of about

2 units. Such a diminution is the highest in composition 5, as the amount of the white pigment is twice lower, which cannot be counterbalanced by an increased amount of filler. On the other hand, the amount of the solvent increases by over 50%, which also influences the optical characteristics of the PVC pastes.

Tables 2A and 2B show that the polyvinyl chlorine and plasticizer types essentially influence the optical properties. The mattness degree of the PVC pastes depends on the polymer–emulsifier compatibility. An improper compatibility between polymer and emulsifier particles leads to a higher mattness degree of the covering.

The mattness degree is enhanced with the increase in the filler – $N_2(TiO_2)$, as evidenced in recipes 3, 4 and 5. The best mattness degree is observed in composition 5. The pastes with a high level of filling and low TiO_2 content are recommended for PVC compact paste tinting – composition 5.

Table 1A
Compositions of PVC pastes for wallpapers

Materials, g	Recipe				
	1	2	3	4	5
1. PVC:					
1.1. Vinnolit E68SA – coarse	100	-	-	100	-
1.2. Vestolit E8001 – medium	-	100	-	-	100
1.3. Vestolit EP7080 – fine	-	-	100	-	-
2. Plastificators:					
2.1. Palatinol N	45	45	45	45	-
2.2. DOP	-	-	-	-	50
3. Filler:					
3.1. Socal N2 – TiO_2	50	50	50	65	75
4. White pigments:					
4.1. Kronos 2220	12.5	12.5	12.5	12.5	6
5. Stabilizer:					
5.1. Baerostab KK47S	2.5	2.5	2.5	2.5	2
6. Others:					
6.1. Diluent: White spirit	10	10	10	10	22.5
6.2. Viscosity regulator: Viskobus 4040	-	-	-	-	2

Table 1B
Compositions of PVC pastes for wallpapers

Materials, g			Recipe					
			6	7	8	9	10	11
1. PVC:								
1.1. Vinnolit E67ST – fine			200	-	100	100	100	100
1.2. Vestolit E7012 – coarse			-	200	100	100	100	100
2. Plastificators: Mol. Mass; Gel. ability								
2.1. DOP	++	++	80	80	80	-	-	-
2.2. BBP	+	+++	30	30	30	-	30	30
2.3. DOP	++	++	-	-	-	110	80	-
2.4. DINP	+++	+	-	-	-	-	-	80
3. Filler:								
3.1. Omyacarb 3EXKA – $CaCO_3$			30	30	30	30	30	30
3.2. Socal 311 – TiO_2			20	20	20	20	20	20
4. White pigments:								

4.1. Kronos 2220	20	20	20	20	20	20
5. Porofor:						
5.1. Porofor ADC/MC-C	8	8	8	8	8	8
6. Stabilizer:						
6.1. Baerostab KK47S	4	4	4	4	4	4
7. Others:						
7.1. Diluent: White spirit	15	15	15	15	15	15
7.2. Viscosity regulator: Viskobus 4040	2	2	2	2	2	2

Table 2A
Optical properties of samples according to recipes 1-5

Recipe	Whiteness, %	Yellowness, %	Mattness, degrees	
			white samples	blue samples
1	84.78	4.87	46	41
2	84.14	3.97	22	39
3	84.52	5.13	31	26
4	85	4.98	30	27
5	81.83	6.38	24	19

Table 2B
Optical properties of samples according to recipes 6-11

Recipe	Whiteness, %	Yellowness, %	Mattness, degrees	
			white samples	blue samples
6	83.22	6.08	86	87
7	82.67	7.19	62	67
8	83.36	6.55	67	77
9	83.45	6.09	76	75
10	83.56	6.18	76	79
11	83.13	6.15	75	76

Table 2B illustrates that the structure, mattness degree and whiteness level are influenced in different ways by different PVC types. Composition 7 appears as the best structured and matted one, while composition 10 records the highest whiteness level, which supports the conclusion that, in this case, the PVC paste E7012 is the most suitable.

The amount and type of the plasticizer in this composition also influence hardness, covering dryness upon hand touch and the mattness degree of the foamed layer.

CONCLUSIONS

- The recipes considered the most suitable as regards specific parameters sustain a PVC structured wallpaper production, as a function of user requirements, the crucial aspect in the production of wallpapers remaining the quality of the raw materials. For example, coverings made from composition 4 show the highest whiteness, while composition 5 grants the greatest mattness degree.
- PVC paste viscosity depends on the coarseness of the PVC-component particles, which diminishes with their increase, because of lower dispersion, lower stability and lower uniformity.
- The time-dependent stability of the PVC paste viscosity depends on particle coarseness and plasticizer’s molecular mass and gelatinizing ability. The average values of plasticizer’s molecular mass and gelatinizing ability give PVC pastes with

minimal deterioration of viscosity in time.

- Composition 1 may be considered the most suitable, as to its viscosity and optical properties.

REFERENCES

[1] D. Caster, *Special Chem*., February 22, 2007, p. 21.

[2] J. Gullichsen and H. Paulapuro, in "Papermaking Chemistry", Book 4, Tapet Oy, Helsinki, 1999, pp. 14-16.

[3] E. Griff, *Special Chem*., June 15, 2007, p. 8.

[4] E. Petri, "Plastisols coverings", www.new chemistry.ru

[5] O. Meinander, *IPW/Das Papier*, **6**, 44 (2005).

[6] L. Webb, *Pulp Pap*. *Int*., **46**, 15 (2004).