Progress in Organic Coatings 93 (2016) 34–40

Contents lists available at ScienceDirect

Progress in Organic Coatings

journal homepage: www.elsevier.com/locate/porgcoat

Effect of wollastonite extender on the properties of exterior acrylic paints

Sabit Mert Somtürk[a], İnci Yaprak Emek[a], Sanem Senler[a,*], Mesut Eren[a], Salih Zeki Kurt[a], Murat Orbay[a,b]

[a] Betek Boya ve Kimya Sanayi A.Ş., Ankara Asfaltı, Hüseyin Çelik Sok. No. 2, Bostancı, 34742 Istanbul, Turkey
[b] Department of Chemical Engineering, Faculty of Engineering, Istanbul University, Avcılar, 34320 Istanbul, Turkey

ARTICLE INFO

Article history:
Received 4 August 2015
Received in revised form 21 December 2015
Accepted 31 December 2015
Available online 13 January 2016

Keywords:
Wollastonite
Exterior paint
Extender
Water vapor transmission
Weathering
Mold growth

ABSTRACT

Performance of an exterior paint film is seriously affected by its water permeability and water vapor transmission property. Commercial acrylic binders provide adequate protection for the former, but cannot accomplish top level, for the latter. In the present work, the effects of substitution of irregular shaped calcite extenders with acicular shaped wollastonite with two different particle sizes were investigated on opaque and semi-transparent acrylic paints, having high and low PVC values. A profound increase, up to 85% on water vapor transmission of coatings was observed, especially for high PVC samples, along with improvement of hiding power. Results of painted panels exposed to weathering tests, which were followed for 42 months, indicated no loss in weathering properties, but significant mold growth inhibition was obtained in the case of substituting calcite with wollastonite extender.

1. Introduction

Coatings are applied on surfaces mainly for two reasons: (i) constructional purposes such as protection of the substrate from degradation and (ii) esthetic purposes. For an exterior paint, there are many parameters that determine the quality of the paint, such as permeability, adhesion between the paint and the substrate as well as UV and alkaline endurance [1]. Since it directly affects the other parameters, liquid water permeability and water vapor transmission are from the most crucial features of a high quality exterior paint [2]. In addition to the loss of adhesion between the paint and the substrate, micro-organism growth (fungus, mold, etc.) and the aggressive ions introduced by the rain and water soluble gases, such as CO_2, are carried by water that penetrates into the paint [3]. The "breathability" (water vapor and CO_2 permeability) of the paint which is inhibited or facilitated by the binders and pigments, increases the UV- and alkaline endurance of the paint composition.

A paint composition consists of a mixture of binder, pigments, solvents and additives. Binder has been specified to be the main component, which, by itself, can determine the main characteristics of the composition [3]. The pigments in these paint formulations, which can be organic or inorganic, have several functions such as providing color, opacity and gloss for esthetic purposes and protective function against weathering. The significance of the pigment particles depends on the characteristics, such as chemical structure, shape, particle size, dispersion state and concentration in the formulation [4–7]. The concentration of the pigments and other insoluble additives such as extenders in a paint composition is described by *Pigment Volume Concentration* (*PVC*) which is the ratio of the volume of the pigments to the total volume of the non-volatile components [8]. The increase in the volume of binder decreases PVC of the paint composition, which generally results in an increase in the UV-resistance. On the other hand, an increase in the volume of extender increases PVC of the paint composition and leads to a decrease in the weathering resistance of the paint.

Extenders are employed in the paint compositions in order to reduce the cost, modify the volume to optimize the composition and achieve or improve the technical properties [9]. Since their refractive indices are low (less than 1.65) [4], their contribution to hiding power is usually negligible. The well-known extenders are calcite (calcium carbonate), kaolin (aluminum silicate), talc (magnesium silicate), mica (hydrous aluminum potassium silicates), silica (silicon dioxide), and barite (barium sulfate) [4]. Among these, the use of calcite is typical. Since it is a natural compound that is

* Corresponding author.
E-mail address: sanem.senler@betek.com.tr (S. Senler).

http://dx.doi.org/10.1016/j.porgcoat.2015.12.014
0300-9440/

widespread in the world, calcite has been employed as an extender in many industries, including plastics, paper and paints [10]. It has been reported that calcite provides straightforward dispersion, higher opacity, haze-free gloss and shorter drying time in paints [11]. Preferably, calcites having two different sizes are used in exterior paint compositions. The smaller size particles provide contribution to hiding power whereas the larger size particles have lower binder demand.

Wollastonite (calcium metasilicate) is also a naturally occurring mineral and has been first employed in coatings industry in 1950s [12]. As a result of a structure that grows naturally as a chain, the mineral possesses mainly an acicular shape (needle-like) [13]. Depending upon the grade, aspect ratios range from 3:1 up to 20:1 are possible and it was disclosed that mainly due to this property, it enhances mechanical strength, thermal and dimensional stability and provides extra resistance for weathering defects such as cracking and checking [14]. The alkalinity of the mineral also advances the material as a corrosion inhibitor [15]. Wollastonite has been reported to provide improved mar, scratch and gouge resistance and barrier properties with increased scrub resistance. Additionally, the mineral has been employed in paint and coating compositions as titanium dioxide (TiO_2) enhancer [12]. Thus, since various extenders enhance paint properties besides cost reduction, a project to investigate the contribution of some uncommon extenders in water-based exterior acrylic paints was carried out, yielding several very rewarding results. Some of these will be presented in future papers and the results of wollastonite only will be reported here. The main reason for including this mineral into this investigation was the shape of the particles, which was expected to provide micro porosity, which enhances the vapor transfer properties of the paint, by forming a scaffold-like structure in the paint composition.

As mentioned above, permeability in the coating material has critical importance. Although water penetration through an exterior paint is not favored, water vapor transmission is strongly required. In this paper, the effect of the wollastonite extender on acrylic-based exterior paints is studied for low and high PVC paints, which were also expected to have different weathering resistance properties. Thus, two different paint formulations, opaque and semi-transparent, have been prepared with low and high PVC values, and the effects of partial or total replacement of the conventional calcite extender with wollastonite, on water vapor transmission, as well as hiding power, gloss and weathering resistance of the paint films were investigated.

2. Experimental

2.1. Materials

All of the samples were technical grade and used without further purification. The calcite extenders, Calcite A-3 (average particle size 6 μm) and Calcite K-7 (average particle size 27 μm), were purchased from Esen Mikronize Maden A.Ş, Turkey. The wollastonite extenders, NYAD 1250 (average particle size 4 μm) and NYAD M325 (average particle size 26 μm) were obtained from NYCO Minerals, USA. The surfactant, Lopon P, and Ti-Pure R 902 pigment were obtained from BK Giulini, Germany and Dupont, USA, respectively. Thickeners, Tylose H 100000 YP2 and Coatex BR 100, were obtained from Shin-Etsu, Japan and Coatex, France. pH modifier, AMP 90 and film forming agent, Dowanol DPnB, were purchased from Dow Chemical Company, USA. Defoamer Tego Foamex K-7, was obtained from Evonik Endustries, Germany. Binder Orgal PST 50A, biocide Acticide BX, and silicone Silres BS 2144 were purchased from Organik Kimya, Turkey, Thor, Italy and Wacker, Germany, respectively. Mono Ethylene Glycol was obtained from PETKIM Petrokimya Holding A. Ş., Turkey. The inorganic pigment, Bayferrox 110 M was purchased from Lanxess, Germany and organic pigment Hostaperm Scharlach GO was purchased from Clariant, Switzerland.

2.2. Preparation of paints

The experiments were designed with two different formulations to obtain opaque (OP) and semi-transparent base paints (T), to be tinted later with pigment pastes. Each formulation had two subgroups with different pigment volume concentrations (PVC). The subgroups with 62% of PVC value have been abbreviated as OP-H and T-H for high PVC opaque films and high PVC semi-transparent films, respectively. The subgroups which have 48% of PVC have been abbreviated as OP-L and T-L for low PVC opaque films and low PVC semi-transparent films, respectively. As conventional extender, calcite with small average particle size, 6 μm (abbreviated as CS) and large average particle size, 27 μm (abbreviated as CL) have been used. In order to verify the significance of employment of wollastonite, calcite extender has been partially or totally replaced by similar average particle size wollastonite, of 4 μm (abbreviated as WS) and 26 μm (abbreviated as WL). The summary of the formulations is presented in Table 1.

The paints were prepared in a 2 l conventional paint disperser (Dissolver Dispermat CN) with a blade of 70 mm. Water, surfactant, first portion of thickener and pH modifier were loaded to the disperser and mixed at 750 rpm for 5 min to obtain the initial mixture. Then, dispersant, defoamer, pigment, different extenders and a second portion of thickener were added to the initial mixture and dispersed at 3000 rpm for 10–15 min to obtain a grind below 40 μm. Finally, in the let-down stage, several additives including binder, silicone, film forming agent, co-solvent, biocide and defoamer were added into the grind and mixed at 750 rpm for 5 min. Since the formulations were very similar to satisfactory commercial precursors, all the paints were stable and had expected properties, with exception of a semi-transparent paint with highest content of Wollastonite. In this case the dispersion was discontinued due to very high viscosity. When all of the calcite extender was substituted with wollastonite, although there was no significant change in density, the pH of the paints shifted from 9.25–9.50 to 9.70–9.92 range. Some base paints were tinted with inorganic Bayferrox 110 M or

Table 1
The formulations of opaque (OP) and semi-transparent (T) films with high (H) and low (L) PVC values.

Components % (w/w)	OP-H	T-H	OP-L	T-L
Water	12.20	10.20	10.85	10.70
Lopon P	1.00	1.00	1.00	1.00
Tylose H 100000 YP2	0.25	0.25	0.20	0.25
AMP 90	0.20	0.20	0.20	0.20
Coatex BR 3	0.40	0.40	0.40	0.40
Tego Foamex K-7	0.20	0.20	0.10	0.20
Ti-Pure R 902	20.00	–	20.00	–
Calcite A-3 (CS) or Wollastonite NYAD 1250 (WS)[a]	24.00	40.00	21.00	33.00
Calcite K-7 (CL) or Wollastonite NYAD M325 (WL)[a]	13.50	15.50	6.50	11.50
Coatex BR 100 P	0.05	0.05	0.05	0.05
Orgal PST 50A	20.00	24.00	35.00	38.00
Silres BS 2144	4.00	4.00	–	–
Dowanol DPnB	1.20	1.20	1.20	1.20
Mono Ethylene Glycol	2.50	2.50	3.00	3.00
Acticide BX	0.30	0.30	0.30	0.30
Tego Foamex K-7	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00

[a] Calcite particles were replaced with similar size wollastonite particles.