HILL PUBLISHING

Engineering Advances, 2022, 2(1), 116-123
https://www.hillpublisher.com/journals/ea/
ISSN Online: 2768-7961

Role of Particle Size of Magnesium Silicate (Talcum Powder) in Improving the Properties of Latex Paint

Sheraz Ahmed Qureshi

Institute of Chemical Engineering & Technology, University of the Punjab, Lahore, Pakistan.

How to cite this paper: Sheraz Ahmed Qureshi. (2022) Role of Particle Size of Magnesium Silicate (Talcum Powder) in Improving the Properties of Latex Paint. *Engineering Advances*, 2(1), 116-123.
DOI: 10.26855/ea.2022.06.010

Received: February 18, 2022
Accepted: March 15, 2022
Published: April 26, 2022

***Corresponding author:** Sheraz Ahmed Qureshi, Institute of Chemical Engineering & Technology, University of the Punjab, Lahore, Pakistan.
Email: sheraz7_2000@yahoo.com

Abstract

The effect of particle size of latex paint extender (magnesium silicate) was examined for different paint samples. Two magnesium silicate slurries were prepared using nano mill and Conventional Agitator with same formulation. Magnesium silicate of particle size 65 microns was chosen as a reference material. Latex paint samples were prepared with both slurries separately in order to observe the effect of particle size. The nano mill showed exceptionally good results compared to conventional agitator. The particle size of magnesium silicate in nano mill was reduced from 65 microns to 26 microns whereas it was reduced from 65 microns to 30 microns in case of conventional agitator. In addition, the latex paint prepared with nano mill showed better whiteness, wet hiding, dry hiding and gloss compared to conventional agitator. The particle size of latex paint extender, magnesium silicate/Talcum powder, plays a vital role in improving the properties of finished latex paint.

Keywords

Agitator, Hiding, Magnesium silicate, Nano mill, Particle size

1. Introduction

Paint is a liquid which spreads over a substrate in the form of thin layer and it is transformed into a solid adherent film [1]. There are two major functions of paint. One protection and other is decoration. The earliest known use of paints dates back more than 30,000 years to cave paintings in Spain [2]. The ancient Greeks, Romans, and Egyptians used natural resins and raw materials to decorate and identify statues, tools, vessels, and buildings [2, 3]. In China and India, shellac resins and beeswax were used over 2000 years ago as a decorative coating which also doubled as a protective function [4]. The earliest paint formulation dates back roughly 900 years to a German goldsmith and monk, Rodgerus von Helmershausen [2, 3]. His formulation described the manufacturing of paint by mixing linseed oil and amber, referred to as paint boiling, which was further refined and developed into the Industrial Revolution [2, 3]. Synthetic polymer chemistry also developed at this time with Carothers and others in the 1920s [5]. Components of paint are solvent, pigment, filler, additives and binder. A coating is a product based on organic binders, which provides a cohesive, non-absorbent, protective film [2]. Differences in the composition of the various coatings systems are presented in Table 1. Paints are liquid materials that are optically opaque coatings that form when applied by brushing, rolling or spraying [2, 3].

The technical definition of a binder is the non-volatile part of a paint excluding the pigments and filler, which includes the non-volatile additives [2]. Natural oils or fatty oils were important film forming agents which were able to convert a low viscosity liquid into a solid [3]. The different resin systems are either step-growth or chain-growth polymerization [6].

Characteristics common in pigments include extreme optical characteristics, particles smaller than 10 μm, being insoluble in water and most organic solvents, and being chemically inert or chemically stable [7]. A comparison between the organic and inorganic pigments is presented in Table 2 [2].

Colored inorganic pigments are typically variants of iron oxides [3]. Pigments are used for giving color contribution in paints. Common filler materials include carbonates, silicon dioxide, silicic acids, silicates, and sulfates [2, 3, 6]. Fillers are used to give toughness and lower the cost of the paint by increasing the density of the paint. The examples of natural fillers are grounded calcium carbonate, magnesium silicate, etc. The examples of synthetic fillers are precipitated calcium carbonate, aluminium silicate, etc. In a paint application, the pigment and extenders are eventually dispersed in some sort of medium. The dispersion process involves 3 steps—wetting, separation, and stabilization [6]. The refractive index can be described as the degree of bending of light as it passes through a material. The refractive index of pigments and film formers are presented in Table 3.

Table 1. Typical composition of various coating systems

Material Category	Coating Type		
	Pigmented paint	**Powder coating**	**Clear coat**
Resin	Yes	Yes	Yes
Additive	Yes	Yes	Yes
Solvent	Yes	No	Yes
Pigment & Extender	Yes	Yes	No

Table 2. Comparison between inorganic and organic pigments

Property	Inorganic Pigment	Organic Pigment
Particle Size	Larger	Smaller
Scattering Power	Higher	Lower
Color Intensity	Lower	Higher
Surface Characteristic	Hydrophilic	Hydrophobic
Heat Resistance	Higher	Lower

Table 3. Refractive Index (R.I.) of Common Materials in Paint

Pigments	R.I.	Media	R.I.
Silica	1.49	Vacuum	1
Calcium Carbonate	1.63	Air	1
Clay	1.65	Water	1.33
lithopone	1.84	Polyvinyl acetate resin	1.47
Zinc oxide	2.02	Vinyl resin	1.48
Zinc sulfide	2.37	Acrylic resin	1.49
TiO2 (rutile)	2.73	Styrene butadiene resin	1.53

TiO2 is not used as a biocide, but has some antimicrobial properties due to the photo catalytic reaction mentioned earlier [8, 9]. Pigment volume concentration (PVC) is the most widely accepted quantitative description of paint film composition [1]. PVC is expressed as volume percentage of the pigments and fillers to that of the volume of the dry film expressed as a whole number. Solvent is used to form a homogenized mixture by dissolving the polymer and pigments. Solvent also adjusts the viscosity of the paint. Additives are liquids which gives dramatic effect on paint quality. Different additives have different impact on the liquid paint or paint film like changing wet edge, increasing stability of the pigments used, antifreezing effect, low foaming, less skinning, etc. There are different types of paint additives like gelling agents, hydroxyethyl cellulose, emulsifiers, different biocides, UV stabilizers, etc. Emulsion paints are water-based paints containing water, binder, additives and pigments. Curing of Emulsion latex paints is done by coalescence. Coalescence is a process in which the coalescing solvent draws together and the binder particles are soften to bind them together into irreversibly bound networked structures. Alkyd enamel are paints that cure by oxidative crosslinking. These paints need drier additives like cobalt naphthenate, calcium naphthenate and lead naphthenate to start oxidation process for drying. Some paints are one or two package coatings. These paints dry through a chemical reaction.

The dispersion behavior of talc powders (Magnesium silicate) has been reported in few literatures [10, 11, 12]. Compared to other silicates, talc is relatively hydrophobic due to the oxide surfaces [13, 14]. The edge face is, however, hydrophilic as a result of the –SiOH and –MgOH groups where the surface potential is pH dependent [15, 16]. Magnesium silicate is a compound of magnesium oxide (MgO) and silicon dioxide (SiO2); it is the magnesium salt of silicic acid containing an unspecified amount of water. The molecular formula may be expressed as MgSiO3xH2O [17]. Magnesium silicate is used as a filler and pigment in dispersive paints [18].

2. Materials and Methods

2.1. The following instruments and analyzers were used to analyze various properties of paint samples.

1) Conventional Agitator, (laboratory mixer manufactured by BEVS Industrial Co. Ltd., China. Model: BEVS 2501/1)
2) Brookfield DV2T viscometer
3) Nano grinding machine (nano mill manufactured by Dongguan Longly Machinery Co. Ltd. China. model no. NT-1L)
4) Spectrophotometer, model data color 110
5) Grind Gauge, sheen UK, range 0-100 μm
6) Hiding Power Charts, sheen UK, Coated, 255 x 140 mm
7) Automatic film applicator (manufactured by BEVS Industrial Co. Ltd., China. Model Number :BEVS1811/2)
8) Tri-Glossmaster , sheen UK, angles 20-60-85°
9) Stop watch
10) Cryptometer , sheen UK, with K007 plates
11) Pyknometer, sheen UK
12) Malvern Mastersizer, Malvern Instruments Ltd. UK.
13) Brookfield KU-1+ viscometer
14) High speed agitator, 1400 rpm

2.2. The following chemicals were used in the preparation of paint samples.

1) Water
2) Dispersant, solution of an ammonium salt of an acrylic polymer in water
3) Magnesium silicate, 65 microns particle size
4) Hydroxyethyl cellulose thickener powder
5) Ammonium hydroxide solution (25% actives)
6) Latex binder, which is ter polymer of vinyl acrylic emulsion
7) Biocide A, a water based combination of chloromethyl-/ methylisothiazolone (CMI/ MI) and O-formal
8) Biocide B, a combination of two isothiazalone derivatives that can provide broad-spectrum micro-organism control in water-based coatings.
9) 2,2,4-Trimethyl-1,3-Pentanediol Monoisobutyrate
10) Monoethylene Glycol

3. Sample Preparation

3.1. Procedure for dispersant determination

Firstly, dispersant demand for magnesium silicate was determined. The dispersant demand was determined by covering the pigment surface completely and measuring the viscosity of pigment slurry to a minimum value. The dispersant was added in small quantities to well agitated pigment slurry. After every addition followed by agitation, the viscosity was measured. The dispersant was added till minimum viscosity or constant viscosity was measured [19]. 800 gm magnesium silicate of particle size 65 micron was added in a mixing tank along with 1160 gm of water (Figure 1). Dispersion of magnesium silicate slurry was done for 05 minutes under 1000 rpm. Viscosity was measured at 25C using Brookfield KU-1+ viscometer following the standard ASTM D562. The effect of increasing in the concentration of 2 gm dispersant on the viscosity of the sample was observed under the same operating conditions as shown in the Table 4.

The procedure was continued till no significant change in viscosity was observed. Figure 2 shows that optimum dispersant demand was 6 gm for 800 gm magnesium silicate of particle size 65 microns.

Figure 1. BEVS laboratory mixer.

Table 4. Dispersant requirement

Dispersant Quantity (gm)	Viscosity (Krebs unit)
0	81
2	63.8
4	59.6
6	57
8	59
10	58.4
12	59

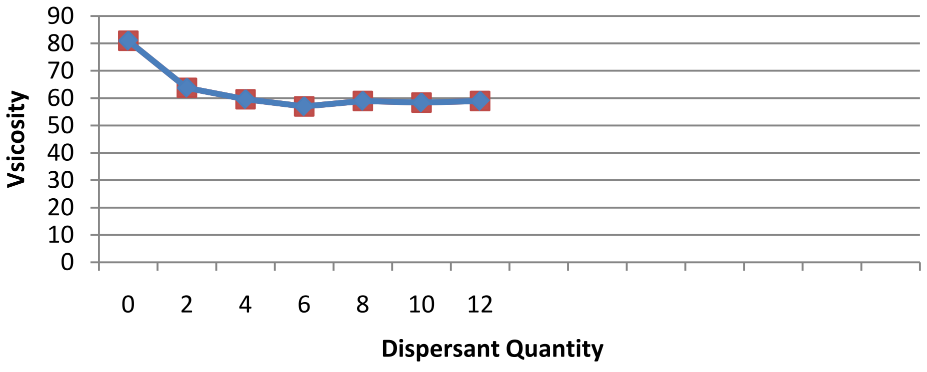

Figure 2. Viscosity versus Dispersant quantity

3.2. Magnesium silicate slurries preparation

The preparation of magnesium silicate slurry was carried out using the formulation given in Table 5. The slurry was prepared using nano mill (Figure 3). Output pneumatic pump pressure was adjusted between 0.2 to 0.4 MPa. RPM of nano shaft was fixed at 2500. Flow rate of nano mill output was around 2 gm/sec. The dispersion of magnesium silicate slurry was determined through ASTM-D 1210. Rate of dispersion was checked using hegman gauge [20] and found to be 10 microns.

With conventional laboratory mixer using the similar formulation (Table 5), Grinding value/dispersion of magnesium silicate slurry was found to be 50 micron.

3.3. Preparation of Paint Samples

Two latex latex paint samples with chemical formulation shown in Table 6 were prepared using high speed agitator with variable rpm speed upto 1400. The magnesium silicate slurry prepared by using nano mill and conventional agitator above was added in these samples separately.

Table 5. Magnesium silicate slurry composition

Ingredients	Quantity in gm
Water	1189
Dispersant	6
Biocide A	1
Ammonium Hydroxide Solution	2
Biocide B	2
Magnesium silicate	800
Total	2000

Figure 3. Nano mill

Table 6. Latex Paint composition

Ingredients	Quantity in gm
Magnesium silicate Slurry	1423
Hydroxyethyl Cellulose	12
Ammonium Hydroxide Solution	16
2,2,4-Trimethyl-1,3-Pentanediol Monoisobutyrate	34
Monoethylene Glycol	50
Latex Binder	465
Total	2000

3.4. Determination of Various Properties of Paint Samples

The latex paints so prepared were applied on hiding power charts with the help of Automatic Film Applicator following the standard ASTM D 823-95 as shown in Figure 4. After panel applications, it was observed that physical properties of latex paints were changed dramatically. Difference in the latex paint properties like wet hiding, gloss, smoothness, drying time, whiteness and opacity were observed. An instrument cryptometer was used to check the wet hiding of latex paint samples. Cryptometers offer a quick method to determine the wet opacity, hiding power and coverage in square meters per liter of liquid coating materials [22]. ASTM D2457 test was followed to test the gloss or sheen of latex paint samples with the help of Tri-Glossmaster equipment. The values of latex paint dry hiding were determined with the help of spectrophotometer data color 110. In order to find out drying time of latex paint samples, stop watch was used. Standard test ASTM D1084 was followed to measure viscosities of samples by using Brookfield DV2T viscometer. Densities of the paint samples were determined using Pyknometer following the standard ASTM D1475. Malvern Mastersizer particle size analyzer was used to determine the particle sizes of magnesium silicate slurries. pH values of the samples were measured through pH meter following the standard ASTM ASTM E70 - 07(2015). The results so obtained are summarized in Table 7.

1 2 1 2

Figure 4. Comparison of Wet panel (left) and Dried panel (right) for nano mill (1) and conventional agitator (2).

Table 7. Specifications of paint samples manufactured through Nano Mill and Conventional Agitator

	Paint manufactured with Nano Mill slurry	Paint manufactured with Conventional Agitator slurry
Viscosity	42000 centipoise	6000 centipoise
Density	1.154	0.982
pH	8.88	8.9
Opacity	49.27	23.02
Whiteness	48.9	24.6
	Gloss	
At 20º	1.70	1.60
At 60º	5	3
At 85º	32.1	3.2
Wet Hiding	46 @ K007	50 @ K007
Dispersion	10 microns	50 microns
Particle Size		
D97	26 micron	30 micron

4. Discussion and Results

The examples of natural fillers are grounded calcium carbonate, magnesium silicate [23]. Magnesium silicate (talc) is hydrophobic and chemically inert [24]. The dispersion chemistry of talc of different particle sizes was studied with wetting agent (non-ionic triblock copolymer) and anionic dispersant (sodium salt of polyacrylic acid). It could be observed from Figure 4 that latex paint made with magnesium silicate slurry processed through nano mill showed a significant increase in physical properties i.e. wet opacity, dry opacity, gloss, smoothness and drying time while latex paint containing magnesium silicate slurry processed by conventional agitator showed no significant improvement in quality of latex paint.

5. Conclusion

Physical properties of latex paint were improved with the reduction of particle size of magnesium silicate. Exceptionally good results were observed when magnesium silicate slurry processed through nano mill was used as compared to conventional agitator. The particle size of magnesium silicate slurry was reduced from 65 microns to 26 microns in nano mill and from 65 microns to 30 microns in conventional agitator. Physical properties i.e. whiteness, wet hiding, dry hiding and gloss was increased, in case of latex paint prepared with nano mill slurry.

References

[1] Morgans, W. M. (1990). Outlines of paint technology, third ed. Griffin, London.

[2] Brock, T., Groteklaes, M., and Mischke, P. (2010). European Coatings Handbook (2nded.). Lamspringe, Germany: Quensen-Druck.

[3] Goldschmidt, A. and Streitberger, H.-J. (2007). BASF Handbook on Basics of Coating Technology. Paderborn, Germany: Bonifatius GmbH.

[4] Gennadios, A., Hanna, M. A., and Kurth, L. B. (1997). Application of Edible Coatings on Meats, Poultry and Sea foods: A Review. LWT - Food Science and Technology.

[5] Painter, P. C. and Coleman, M. M. (2000). Fundamentals of Polymer Science (2nd ed.). Boca Raton, Florida.

[6] Wicks, Z. W., Jones, F. N., Pappas, S. P., and Wicks, D. A. (2007). Organic Coatings: Science and Technology (3rd ed.). Hoboken, NJ: Wiley.

[7] Braun, J. H. (1993). Introduction to Pigments. Blue Bell, PA: Federation Series on Coatings Technology.

[8] Chung, C.-J., Lin, H.-I., Tsou, H.-K., Shi, Z.-Y., and He, J.-L. (2008). An antimicrobial TiO2 coating for reducing hospital-acquired infection. Journal of biomedical materials research. Part B, Applied biomaterials, 85(1), 220-4.

[9] Xing, Y., Li, X., Zhang, L., Xu, Q., Che, Z., Li, W., Bai, Y., et al. (2012). Effect of TiO2 nanoparticles on the antibacterial and physical properties of polyethylene-based film. Progress in Organic Coatings, 73(2-3), 219-224.

[10] Charnay, C. and Lagerge, S. (2003). J. Disper. Sci. Technol., 24(2), 273.

[11] Goalard, C., Samimi, A., Galet, L., Dodds, J. A., Ghadiri, M. (2006). Part. Part. Syst. Char. 23, 154.

[12] Chauhan, V. S., Chakrabarti, S. K., Bhardwaj, N. K. (2012). IPPTA J. 24(1), 171.

[13] Trivedi, N. C. (1997). In: O'Shea, J.E., Hagenmeyer, Robert W. (Eds.), Pigments for Paper. Tappi Press, Atlanta, GA, p. 199.

[14] Ciullo, P. A. and Robinson, S. (2003). Paint & Coating Industry Magazine, Available online http://www.pcimag.com/articles/print/talcshape-and-form-meet-function [16/10/2012].

[15] Ma¨lhammar, G. (1990). Colloid Surface 44, 61.

[16] Fuerstenau, M. C., Lopez-Valdivieso, A., Fuerstenau, D. W. (1988). Int. J. Miner. Process., 23(3-4), 161.

[17] Taspinar, O. O., Ozgul-Yucel, S. (2008). Lipid adsorption capacities of magnesium silicate and activated carbon prepared from the same rice hull. Eur. J. Lipid Sci. Technol., 110, 742-746.

[18] Krysztafkiewicz, A., Lipska L. K., Ciesielczyk, F., Jesionowski, T. (2004). Amorphous magnesium silicate – synthesis, physicochemical properties and surface morphology, Advanced Powder Technology, 15, 549-565.

[19] Holzinger, F. and Dorr, H. (1990). Kronos Titanium Dioxide in Emulsion Paints, optimal formulation for quality and efficiency. Leverkusen 1, Germany.

[20] Robert B. McKay. (1994). Technological Applications of Dispersions, p. 43 (citing ASTM D1210-79 (1988)). Marcel Dekker, Inc.

[21] Peter A. Ciullo. (1996). Industrial Minerals and Their Uses: A Handbook and Formulary, pp. 155-56. Noyes Publication.

[22] Pfund, A. H. (1930). “Hiding power measurements in theory and practice,” *Proceedings*, American society for testing and materials, Vol. 30, Part II, p. 882.

[23] Qureshi, S. A. (2021). Effect of Operating Parameters and Particle Size of Calcium Carbonate on the Physical Properties of Latex Paint. Biomed J Sci & Tech Res., 39(1). BJSTR. MS.ID.006235.

[24] Chauhan, V. S., KantBhardwaj, N. (2017). Efficacy of dispersion of magnesium silicate (talc) in papermaking, Arabian Journal of Chemistry, Volume 10, Supplement 1, February 2017, Pages S1059-S1066.