Article:
Manga, MS orcid.org/0000-0001-8976-4792, Willis, D, Nurafiqah, MA et al. (1 more author) (2019) The impact of raw material properties and process conditions on the color of a powdered formulated detergent product. Particuology, 45. pp. 35-41. ISSN 1674-2001

https://doi.org/10.1016/j.partic.2019.01.002

Supplementary information

The impact of raw material properties and process conditions on the color of a powdered formulated detergent product

Mohamed. S. Manga*, David. Willis, Nurafiqah. M. Ali and David. W. York

School of Chemical and Process Engineering, Faculty of Engineering, University of Leeds, Woodhouse Lane, Leeds, LS2 9JT, United Kingdom.

Corresponding Author

* Email: M.S.Manga@leeds.ac.uk

S1. Materials and associated properties

Table S1. Liquid and powder components used in this study to produce granular detergent powder.

Raw materials: Liquid components				
Chemical	**Functionality**	**Appearance**	**Grade**	**Size**
Linear Alkylbenzene Benzene Sulfonic Acid (HLAS)	Synthetic anionic surfactant	Brown viscous liquid with shade of color dependent on purity	Commercial, Research, (purity >96%)	- -
Oxyethylated isononylphenol (Neonol AF 9-12)	Non-ionic surfactant	Colorless Oily liquid	Commercial	-
Sodium silicate	Builder	White translucent viscous liquid (translucency dependent on purity)	Commercial, Research, (purity >98%)	- -
Sokolan	Auxiliary additive (Non-ionic copolymer used as	Yellowish viscous liquid	Commercial	-

	antiredoposition agent)			
	Raw materials: Solid components			
Carboxy methyl cellulose (CMC)	Auxiliary additive (antiredoposition agent)	White granular powder	Commercial	Median particle size = 70 μm
Sodium carbonate	Builder	White granular powder	Commercial, Research, (purity >99%)	Median particle size = 300 μm
Sodium sulfate	Builder	White granular powder	Commercial, Research (purity >99%)	Particle size 250-2000 μm ≥ 85 %
Sodium tripolyphosphate (STPP)	Builder	White powder	Commercial	Mean particle size = 5 μm
Tinopal® CBS-X (optical brightener)	Auxiliary additive	Yellow-green powder	Commercial	Median particle size

= 50 – 75 μm

Typical recipe for formulation is;

Ratio of Powder to Liquid	1.94 : 1
Raw Material	Mass of component (g)
Solid Portion	
STPP	11.91
CMC	0.97
Tinopal	0.13
Na_2CO_3	27.09
Na_2SO_4	34.98
Liquid Portion	
HLAS	11.14
Sodium Silicate	21.14
Sokalan	4.95
Neonol AF 9-12	1.40

S2. Breakdown of the samples used for color analysis

Table S2. Breakdown of the different samples that are used for color analysis

	Ingredients		Agglomerator	Drying temperature	Comments
	Dry	**Wet**			
Sample 1	All Commercial grade and all added	All commercial grade and all added	Food processor	Drying at 70°C using convection oven	
Sample 2	All Commercial grade and all added	All commercial grade and all added	Food processor	Drying at 120°C using convection oven	
Sample 3	All Commercial grade and all added	All commercial grade and all added	Food processor	Drying at 150°C using convection oven	
Sample 4	All Commercial grade and all added	All commercial grade and all added	Food processor	Drying at 170°C using convection oven	
Sample 5	All Commercial grade and all added	All commercial grade and all added	Food processor	Drying at 60° using fluidised bed	
Sample 6	All Commercial grade and all added	All commercial grade and all added	Food processor	Drying at 70° using fluidised bed	
Sample 7	All Commercial grade and all added	All commercial grade and all added	Food processor	Drying at 80° using fluidised bed	
Sample 8	All Commercial grade and all added	All commercial grade and all added	Food processor	Drying at 100° using fluidised bed	
Sample 9	All Commercial grade and all added	All commercial grade and all added	Food processor	Drying at 120° using fluidised bed	
Sample 10	All Commercial grade and all added	All commercial grade and all added	Food processor	Drying at 70°C using convection oven,	unsieved sample

Sample 11	All Commercial grade and all added	All commercial grade and all added	Food processor	Drying at 70°C using convection oven,	sieved with 841µm sieve for analysis of overs
Sample 12	All Commercial grade and all added	All commercial grade and all added	Food processor	Drying at 70°C using convection oven,	sieved with a 841 and a 500µm sieve
Sample 13	All Commercial grade and all added	All commercial grade and all added	Food processor	Drying at 70°C using convection oven,	sieved with a 500 and a 250µm sieve
Sample 14	All Commercial grade and all added	All commercial grade and all added	Food processor	Drying at 70°C using convection oven,	sieved with a 250µm sieve for analysis of fines
Sample 15	All Commercial grade and all added	All commercial grade and all added	Food processor	Drying at 70°C using convection oven,	This sample had less amount of tinopal added (0.09g) which results in a decrease in the L observed compared to above samples
Sample 16	All Commercial grade and all added	All commercial grade and all added	Blender	Drying at 70°C using convection oven,	Recipe kept as the same as sample 15
Sample 17	All Commercial grade and all added	All commercial grade and all added	Coffee grinder	Drying at 70°C using convection oven,	Recipe kept as the same as sample 15
Sample 18	All Commercial grade and all added	All commercial grade and all added	Food processor	Drying at 70°C using convection oven,	Tinopal was added as a powder. Also quantity of HLAS added was lower (8g).
Sample 19	All Commercial grade and all added with exception of Tinopal	All commercial grade; All added with Tinopal added in water	Food processor	Drying at 70°C using convection oven,	Tinopal was dispersed in water recipe same as sample 18
Sample 20	All Commercial grade and all added with exception of Tinopal	All commercial grade; All added with Tinopal added in Neonol	Food processor	Drying at 70°C using convection oven,	Tinopal in neonol (same as sample 18)

Sample 21	All Commercial grade and all added with exception of Tinopal	All commercial grade; All added with Tinopal added in Sokolan	Food processor	Drying at 70°C using convection oven,	Tinopal in Sokolan polymer (same as sample 18)
Sample 22	All Commercial grade and all added with exception of Tinopal	All commercial grade and all added	Food processor	Drying at 70°C using convection oven,	No Tinopal added (same as sample 18)
Sample 23	All Commercial grade and all added with exception of Tinopal	All commercial grade; All added with Tinopal added in Neonol	Food processor	Drying at 70°C using convection oven,	Same as sample 20
Sample 24	All Commercial grade and all added with exception of Tinopal	All commercial grade; All added with Tinopal added in Neonol	Food processor	Drying at 70°C using convection oven,	Same as sample 23 but sprayed on rather than poured in
Sample 25	All Commercial grade and all added with exception of Tinopal	All commercial grade; All added with Tinopal added in Neonol	Food processor	Drying at 70°C using convection oven,	Same as sample 24 but addinal spray on of Tinopal in Neonol
Sample 26	All Commercial grade and all added with exception of Tinopal	All commercial grade; All added with Tinopal added in Neonol	Food processor	Drying at 70°C using convection oven,	Same as sample 25 but addinal spray on of Tinopal in Neonol
Sample 27	All commercial grade and all added	HLAS research grade rest is commercial grade and all added	Food processor	Drying at 70°C using convection oven,	HLAS research grade

Sample 28	Sodium carbonate research grade rest are all commercial grade and all added	All commercial grade and all added	Food processor	Drying at 70°C using convection oven,	Sodium carbonate research grade
Sample 29	Sodium sulphate research grade rest are all commercial grade and all added	All commercial grade; All added with Tinopal added in Neonol	Food processor	Drying at 70°C using convection oven,	Sodium sulphate research grade
Sample 30	All Commercial grade and all added	Sodium silicate research grade rest is commercial grade and all added	Food processor	Drying at 70°C using convection oven,	Sodium silicate research grade
Sample 31	Sodium carbonate and sodium sulphate research grade rest are all commercial grade and all added	HLAS and Sodium silicate research grade, rest is commercial grade and all added	Food processor	Drying at 70°C using convection oven,	Sodium carbonate, sodium sulphate, HLAS and Sodium silicate of research grade

S3. Dispersion of Tinopal study

Preliminary experiment was conducted to determine which of the liquids would produce a stable dispersion of Tinopal optical brightener. The stability of the dispersions were compared at before and after heating the liquids to 50°C. Based on this, it was found that water (dissolution), Neonol and Sokolan (uniform dispersions) could be used as a delivery vehicle to incorporate Tinopal within the powdered detergent formulation. Although sodium silicate and HLAS could be used to disperse the Tinopal, the dispersion was not uniform throughout the liquid and it was perceived that this could exaggerate any powder discoloration during the manufacturing process.

Before Heating

Tinopal in water	Tinopal in sodium silicate	Tinopal in HLAS
		
Tinopal in Neonol	**Tinopal in Sokalan CP5**	**Tinopal in Sokalan HP 22**
		

After Heating

Tinopal in water	Tinopal in sodium silicate	Tinopal in HLAS
		
Tinopal in Neonol	**Tinopal in Sokalan CP5**	**Tinopal in Sokalan HP 22**
		

Figure S3. Assessing the ability of Tinopal to disperse in a range of liquid materials at low and elevated temperatures [Publish in color]

S4. Impact of Tinopal dispersed in water on powder color

Tinopal is soluble in water and this yellow-green color is imparted on the resulting powder.

Figure S4. Digital photographs of powder samples when Tinopal is a) not dispersed in water (sample 18) and, b) dispersed in water (sample 19). [Publish in color]