Improvement of Surface Features of Nitrogenous Fertilisers and Influence of Surfactant Composition on Fertiliser Surface

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Abstract

One of the most important problems and main requirements in today's fertiliser industry is the stabilization of a product under storage conditions after its production and the changing of its chemical construction due to the impression of the ambient condition. In this research, we developed different chemical compositions from known constructions, examined them, and indicated the results qualitatively and quantitatively.

Keywords: Surface stabilization, Flowability, Caking tendency, Free swelling index, Optical dust index

1. Introduction

Surface coating is a surface treatment that is applied to improve the surface properties of solid fertilisers. The coating material could be a liquid, solid, or thermoplastic additive (Granquist. V., 2003). There can be a lot of different aims of improving surface properties by coating on manufacture prilled chemical material. In this study, our first aim is to show that a fertiliser surface can be coated with a surfactant to increase the fluidity of prilled fertilisers, ensure and increase the stabilization of the surface against chemical reactions decrease the moisture retained on the fertiliser's surface, minimize caking and degradation due to reactions that occur between prilled fertilisers and that cause moisture retention, dissolve easily into the surface of the soil during end use, improve the compatibility of the surface, improve the appearance, increase commercial qualitativeness as much as storage life, save nutrient values, and heal properties like the maximum influence on the application area.

Chemical coating is applied so that the manufacture fertiliser's import, storage, and packaging, preserve its quality during its use (Levin, 1969). Typically, a coating cannot impress to the chemical stabilization during the production of prilled or granulated fertilisers. Here, the first aim is to keep the surface features stable until it reaches the customer, to be able to dissolve it easily in to water when it is given to soil, and to ensure that nutrient values do not decrease. Other process features such as fertiliser shape, surface deformation, excessive porosity, higher moisture content, weak process control, and the increase in unwanted reactions are not the first aims for surface coating (Ando, J., Siegal, J. P., & Jordan, J.E., 1965, pp.186). In some cases, like the control of process variables, the chemical additives in process can help decrease the abovementioned problems as well.

2. Examination

The examination was made by injecting 300 ppm (figure 1), 400 ppm (figure 2), and 500 ppm (figure 3) of a glycerine (5 ml), wax (5 ml), molasses (5 ml) and clay (5 ml) mixture into prilled ammonium nitrate at 80 ^{0}C. The best result was taken at 400 ppm, according to the mixture concentration and flowability of prilled

AN(figure 4). The chemical construction of the film of a mixture of glycerine, wax, clay, and molasses occuring on the fertiliser's surface is shown by reaction 1.

$$Al_2O_3\bullet 2SiO_2+C_3H_8O_3+C_6H_{10}O_5+C_{25}H_{52}+NH_3NO_4 \longrightarrow (Al_2O_3\bullet 2SiO+C_3H_7O_2+C_6H_8O_5+C_{25}H_{50}) + 5H_2O \quad \text{..... reaction(1)}$$

$$|$$

$$NH_3NO_3$$

We examined 5 ml of each compound that occurs in the mixture, and the results are shown in figures 4,5,6, and 7. Figure 4 shows the degradation tendency of the fertiliser coated with 5 ml of glycerine, figure 5 shows the degradation tendency of the fertiliser coated with 5 ml of wax, figure 6 shows the degradation tendency of the fertiliser coated with 5 ml of clay, and figure 7 shows the degradation tendency of the fertiliser coated with 5 ml of molasses.

2.1 Measuring the amount of caking (free swelling index)

The amount of caking of the fertiliser samples that were kept in storage under a 2 kg/m^2 pressure for 14 days was evaluated by the ' free swelling index '. Upon the determination of the free swelling index, the unrestrained swelling examination was applied to fertiliser samples. In the unrestrained swelling examination, samples were pressed under 2 kg/m2 pressure. Then, a volume of water equal to 10% of the sample's volume was added and the increase in the sample's volume was measured. The free swelling index is expressed below:

Free swelling (%) = (ΔH/H)100 (1)

where

ΔH = swelling height dependent on saturation, and

H = sample's initial height.

The examined fertiliser sample's free swelling index (FSI) is shown in Table 3.

2.2 Measuring degradation of fertiliser samples

The amount of degradation of a fertiliser surface is evaluated by the optical dust index (Draine, 2007). We have computed the dust index and the absorption section dust index for the prilled grains of these materials ranging from 0 to 15 microns. Optical dust indexes have been computed as described by Laor & Driane (1993). The calculated optical dust indexes are shown in Table 5.

To determine the optical dust index by examining was used JSDX mark, 100S4 model Laser microprop (atomic emission spectrometer) equipment. On this equipment, plasma (gaseous ion current) was used for atomizing and alerting the sample on this equipment. Plasma has been occured by argon and plasma was used for atomizing and alerting of fertiliser sample. On this instrumental analysis method, fertiliser sample was placed between two electrodes. Samples was vaporized by plasma. Then vaporized sample was alerted at 350 nm by alternative current which occurs between two electrodes. And measures was taken. Results is as shown in Table 2 and Table 5.

2.3 Measuring of crushing strenght

To measure crushing strength of fertiliser prills, average 2 mm diameter of fertiliser was examined on testing device like on Turkish Standard 9128. The examining prill was waited for 1 hour at 0 C. After cooling, each prill was examined in 10 sn. The ball which used for hitting was left in PVC pipe dropping conducter on prill surface. The cracking time of prill surface was saved depending on applied force. The saved value shows crushing strength of prill. Here,750 mm of dropping height of ball, 400 g of ball mass were received as Standard(TS 9128).

3. Discussion

According to the construction of the coated chemical material and the form of the fertiliser's surface, there were differences in the results of processes(Ando, J., Miyamura, T., & Akiyama, T., 1967). In an examination under laboratory conditions, when a fertiliser surface was coated with particles such as talc, and clay, we observed good flowability and low caking between prills or granules, and, this ensured a non-adhering property(Ando, J.,& Sai, G., 1970, pp.2614). However, but it was observed to increase with the degradation of the fertiliser. When it used as a coated chemical agent, petroleum oil such as fuel oil ($C_{20}H_{42}$), asphaltic oil ($C_{200}H_{246}N_2S_7O_4$),

refined oil (C_8H_{18}), and natural oil ($C_{24}H_{48}O_2$), lost flowability between prills and did not prevent caking; however, it ensured low degradation(Coats, R.V., & Woodard, G.D., 1965, pp. 1315). Therefore, in this study, in the place of petroleum oils, we worked on a new composition for coating.

When we used thermoplastic solutions such as surfactants, resins, polymers, wax, and waxy surfactants, degradation and caking problems reduced; however, because of a higher production cost, this was researched as an alternative process. The solution examined under laboratory conditions as another- fertiliser coating chemical was a glycerine, molasses, surfactant and polymer mixture. These results were similar to the results of thermoplastic coating. Nevertheless, because of its higher cost, this chemical was similarly not used for larger scale production. On the other hand, the polymer solutions that stop moisture diffusion into a fertiliser surface by the crosslinking on the fertiliser surface are not preferable because of their higher cost and difficult process. The result is shown in Table 1.

In the other test, in which we researched dust emission, we examined prilled ammonium nitrate that was uncoated, coated with glycerine, coated with wax, coated with molasses, and coated with a mixture of glycerine, wax, and molasses. Dust emission results are shown in Table 2. The other important result that we observed in our examination was the rotating drum, which is used in fertiliser manufacturing factories and is effective against dust emission(Yanagi, T., 1965, pp. 264). In optical dust examinations; fertiliser is fed to the rotating drum powdered, and then examined by measuring light absorbance and abrasion on the fertiliser surface.

In the test for researching the effects of polymeric and thermoplastic material on caking tendency, it was seen that caking decreased when the rate of the polymeric material that was used increased. The results of this test are shown in Table 3.

In the other test, we examined the crushing strength of the fertiliser prills under a 2 kg/m^2 pressure for 40 days(Turkish Standard 9128). The fertiliser prills that were examined were coated with wax, glycerine, clay, and molasses under different conditions, and the test results are shown in Table 4.

For coating the surface of the fertiliser, a rotating drum is usually in the fertiliser manufacturing process (Brusset, Leveau, Spinat, Trani, & Verollet., 2002). Inside this drum, there is a nozzle that sprays the coating material, a blender that ensures good surface contact between fertiliser prills, coating material, and a screw conveyor. Fertiliser prills were brought by this screw conveyor into the rotating drum and coating material was sprayed on the fertiliser prills inside the drum. The preference of the coating material is dependent on its viscosity/temperature rate, and spreadability on a surface, type of nozzle used for spraying, the nozzle number, and the temperature and concentration of the coated chemical.

Careful fertiliser storage and import are important. The flowability, degradation, abrasion, and stabilization features or quality related properties need to improve for cases involving transfer and handling. In today's today's fertiliser markets, these are the most important problems that producers need to address (Theoret, A., & Sandorfy., 1963).

The first aim of the fertiliser industry for avoiding the use of petroleum oils that affect nutrient values and other quality features and for controlling dust emission, is to control the toxic materials in leaked underground water and to save the nutrient values of fertilisers. The first aim of this research is to work with the environment, and determine the chemical composition that does not affect nutrient values. We have developed a new composition that fertiliser producers find easily applicable.

4. Conclusion

In this research, we studied a new chemical composition for improving the fertiliser surface by taking in to consideration features such as cutting the contact between air and the fertiliser during storage,water solubility, and preservation of nutrients in the fertiliser until their end use. By the final technology, we achieved our first aim of minimizing the effects of chemicals such as petroleum oils on nutrient values by developing a new, easily applicable composition while considering production costs. Therefore, we used

5 ml of glycerine,

5 ml of wax,

5 ml of molasses, and

5 ml of clay

The application of a 400 ppm concentration of this mixture, at 80 ^{0}C ensured the required results.

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Table 1. Type of coating and its effects on fertiliser surface

Type of coating	Process and effectiveness
Particle (sometimes called parting agent), clay, talc, etc	Good for flowability and caking, but it increases dust, and a high amount is needed
Coating oils (fuel oil, asphaltic oil, refined oils, natural oils, and fats)	Good for dust, but not so good for caking.
Thermoplastic mixtures (wax, waxy surfactants, sulphur, resins, and polymers)	Good for dust and caking, but somewhat higher cost
Water soluble liquids (glycerine, molasses, surfactant solutions, and polymer solutions)	Good for special applications where solubility is needed
Polymer systems (polymerised film via a reaction with the surface or the cross-linking on surface)	Involves a costly, difficult process, but has high performance

Table 2. Effects of examined materials on degradation (dust emission)

Sample name	mg dust/ kg sample
Uncoated	740
Glycerine ($C_3H_8O_{3)}$	150
Molasses($C_6H_{10}O_5$)	83
Wax ($C_{25}H_{52}$)	84
Glycerine+clay+molasses+wax	31

Table 3. Effects of examined materials about caking (free swelling index)

Sample name	Free swelling index
Uncoated AN	15.2
Wax ($C_{25}H_{52}$)	7.4
Glycerine ($C_3H_8O_{3)}$	0.15
Molasses($C_6H_{10}O_5$)	0.1
Glycerine+clay+molasses+wax	< 0.1

Table 4. Effects of examined about crushing strenght

Results after 40 days under 2 kg/cm2 pressure			
Temperature of fertiliser : 40 °C			
	Pressure(2kg/m2)	Temperature of Coatings	Crushing strength
Glycerine+clay+molasses+wax	2	Ambient	13.2
Glycerine+clay+molasses+wax	2	80 C	18
Uncoated	2	-	14.3
Clay (Al_2O_3 .2SiO_2. 2H_2O)	2	80 C	14
Molasses($C_6H_{10}O_5$)	2	80 C	13.7
Wax ($C_{25}H_{52}$)	2	80 C	14,9
Glycerine($C_3H_8O_{3)}$	2	80 C	16

Table 5. Effects of fertiliser temperature at 40 °C and coating temperature at ambient temperature on degradation

Temperature of Fertiliser : 40 °C			
Temperature of coatings : ambient			
	Pressure	Optical Dust Index (Degradation)	
	Kg/cm2	T0	T40 Days
Glycerine+clay+molasses+wax	2	3.75	8.5
Uncoated	--	679	787
Clay (Al_2O_3 .2SiO_2. 2H_2O)	2	8	15
Molasses ($C_6H_{10}O_5$)	2	8.5	10
Wax ($C_{25}H_{52}$)	2	7	9
Glycerine ($C_3H_8O_3$)	2	4.5	8.5

It is seen at following graphics that degradation effects of used each chemicals to fertiliser surface on optical dust examination in the laboratory conditions.

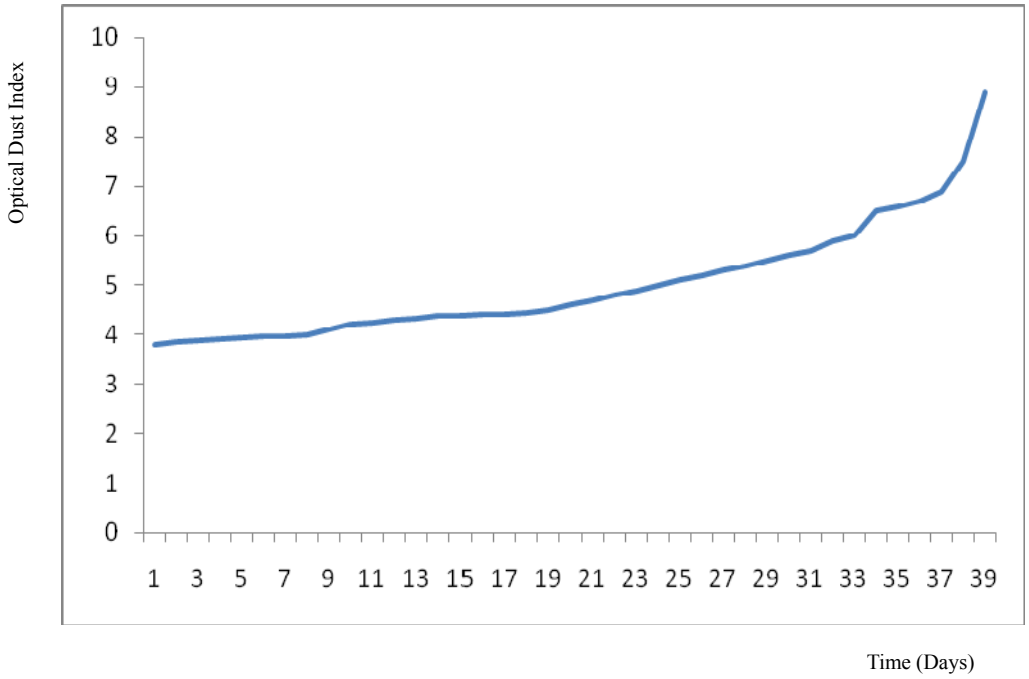


Figure 1. Degradation tendency of fertiliser which coated by 300 ml (Clay (Al_2O_3•2SiO_2• 2H_2O)+Molasses($C_6H_{10}O_5$) +Wax ($C_{25}H_{52}$) + Glycerine ($C_3H_8O_3$)) mixture

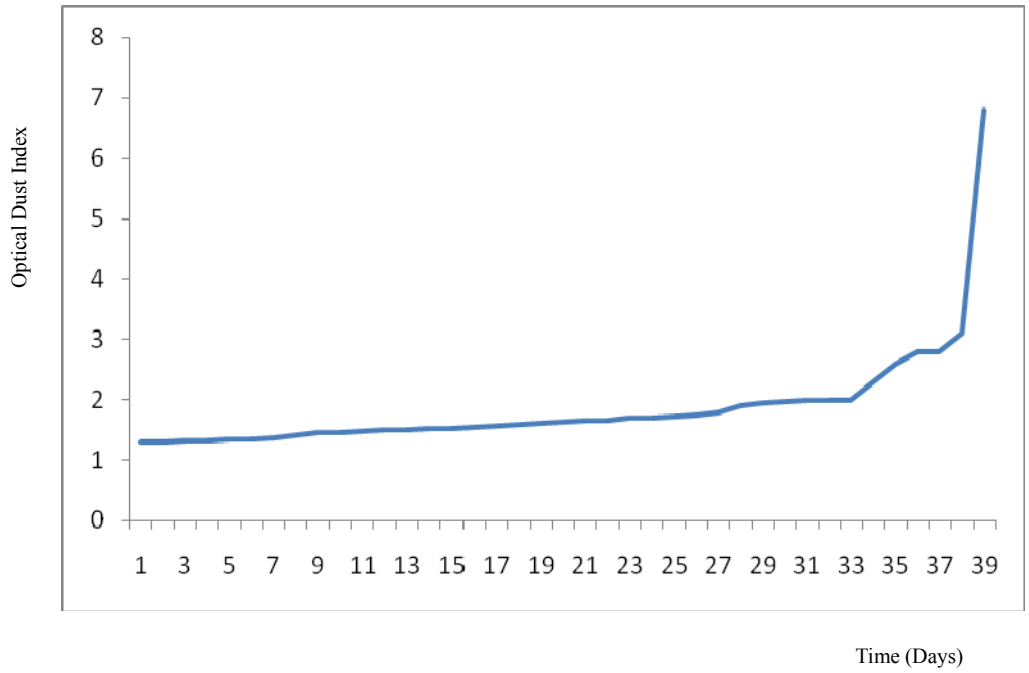


Figure 2. Degradation tendency of fertiliser which coated by 400 ml Clay (Al_2O_3•2SiO_2•2H_2O) + Molasses ($C_6H_{10}O_5$) +Wax ($C_{25}H_{52}$) + Glycerine ($C_3H_8O_3$) mixture

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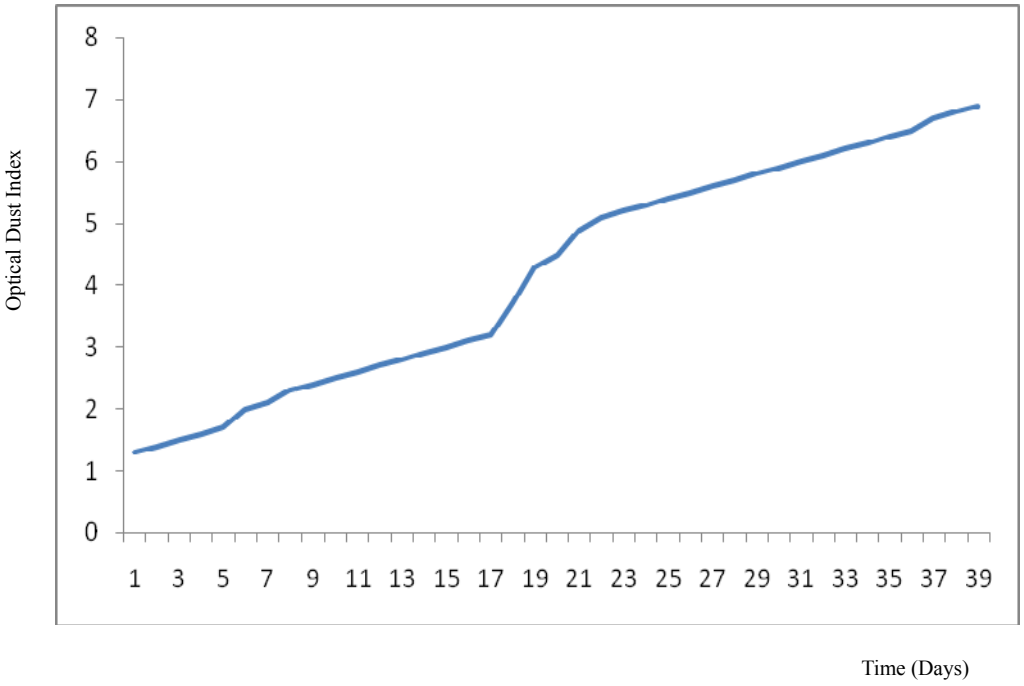


Figure 3. Degradation tendency of fertiliser which coated by 500 ml ($(Al_2O_3 \bullet 2SiO_2 \bullet 2H_2O)$+molasses ($C_6H_{10}O_5$) +wax ($C_{25}H_{52}$) + Glycerine ($C_3H_8O_3$)) mixture

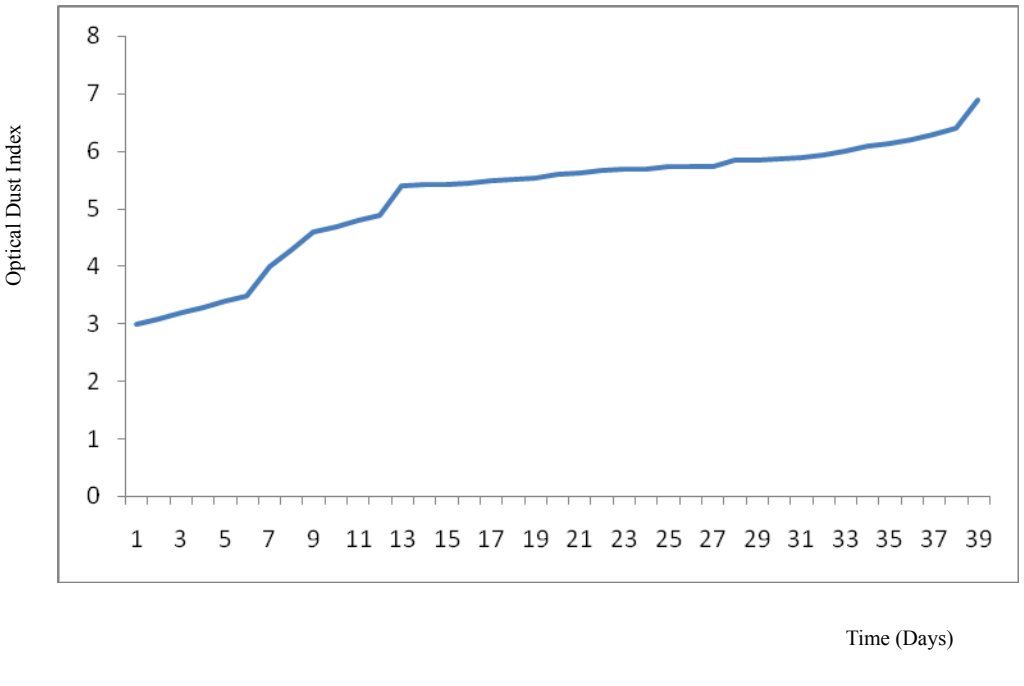


Figure 4. Degradation tendency of fertiliser which coated by 5 ml of Glycerine ($C_3H_8O_3$)

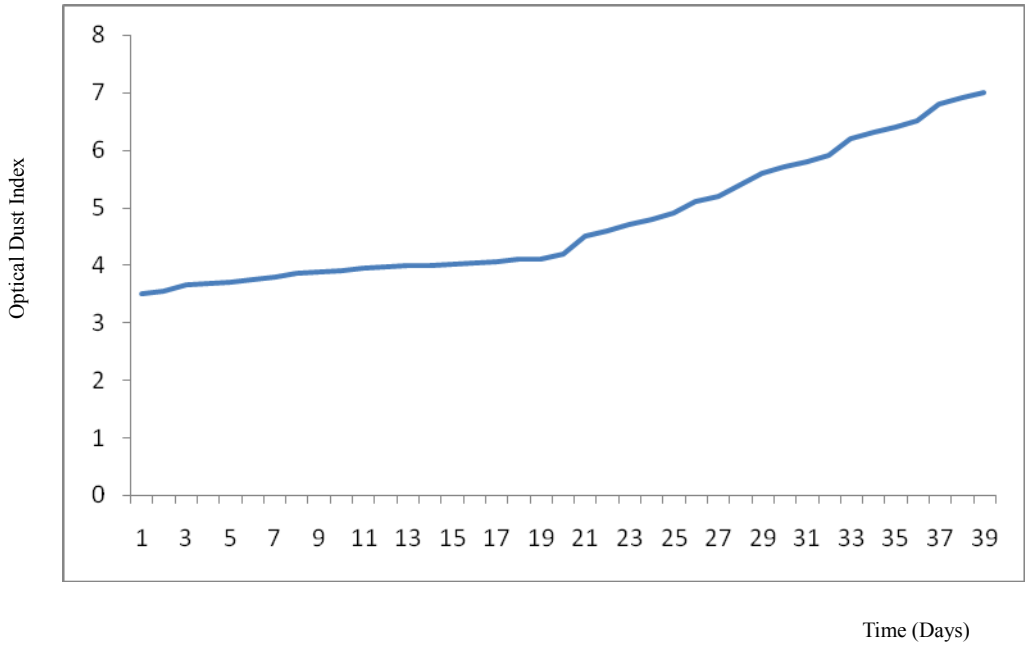


Figure 5. Degradation tendency of fertiliser which coated by 5 ml of wax ($C_{25}H_{52}$)

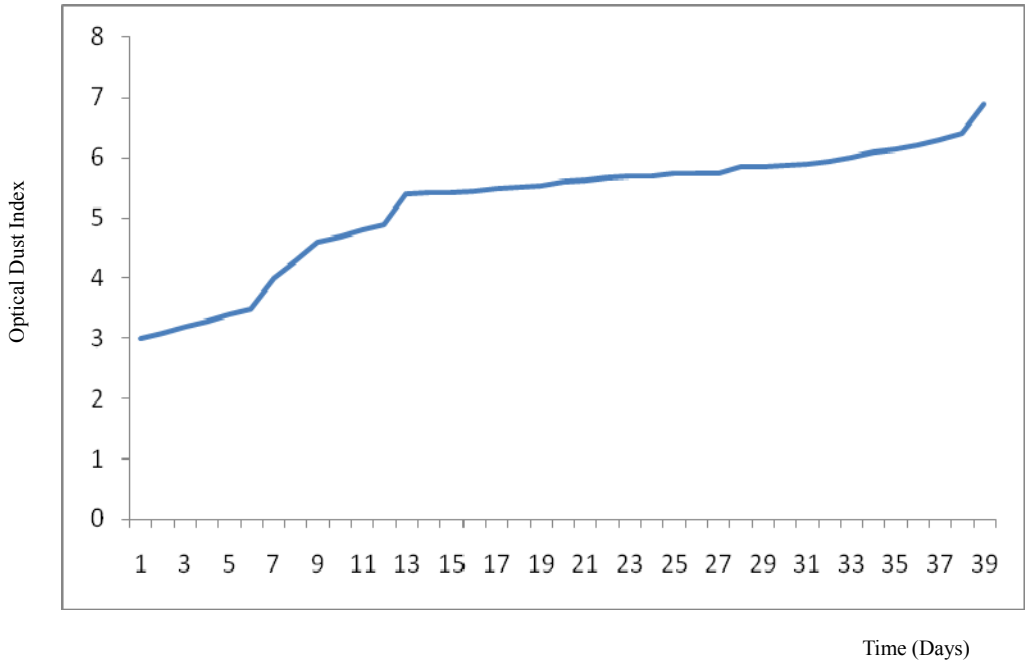


Figure 6. Degradation tendency of fertiliser which coated by 5 ml of clay ($Al_2O_3 \bullet 2SiO_2 \bullet 2H_2O$)

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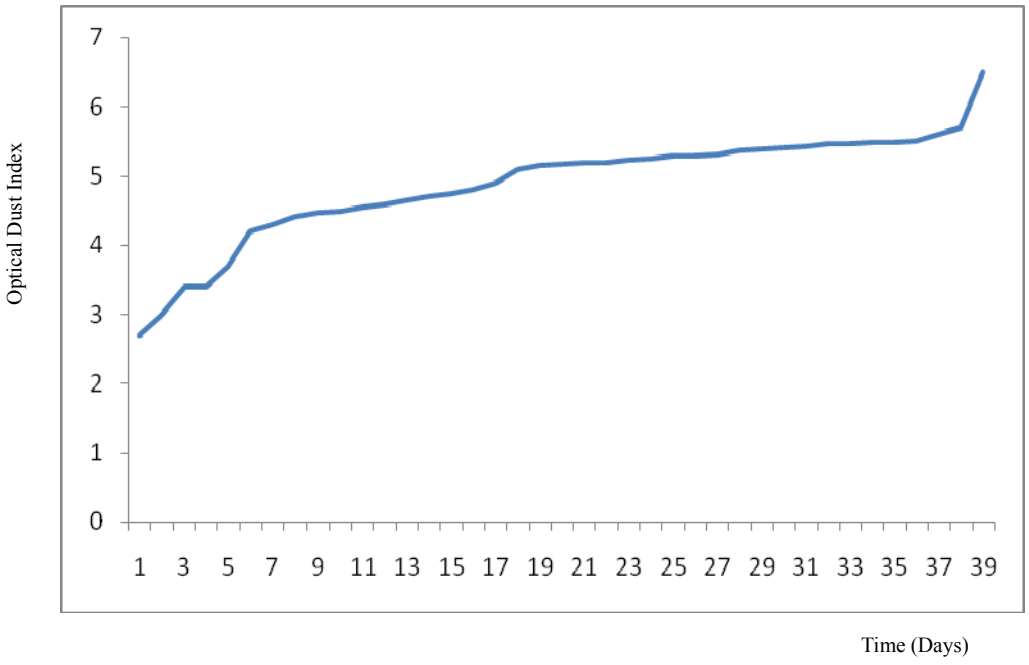


Figure 7. Degradation tendency of fertiliser which coated by 5 ml of molasses ($C_6H_{10}O_5$)