Granulated slow release fertilizer NCaS based on urea and flue gas desulfurization gypsum

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This paper presents the results of a research on a process for production of a calcium sulphate and urea adduct and a method to slow down the release of nitrogen by coating the fertilizer granules with polymers.

In the years 2010-2012, at the Łukasiewicz Institute of New Chemical Syntheses, as part of a development project, the technology of granulated nitrogen-calcium-sulfur fertilizer based on phosphogypsum and urea containing an adduct of calcium sulphate and urea ($CaSO_4 \cdot 4CO(NH_2)$) was developed (Borowik et al., 2012). Agricultural plot research at the Institute of Soil Science and Plant Cultivation State Research Institute showed that fertilizers produced according to the developed technology, that were used before sowing, have been characterized by a slight slowdown in the nitrogen release. The pre-sowing used in one dose in rapeseed and wheat cultivation showed no worse yielding effects than ammonium nitrate used in two doses. However, the granules of this fertilizer were characterized by an unfavourable shape, significant porosity and a rough surface (Fig. 1).

The encouraging results of agricultural research prompted us to work on developing the adduct granulation technique and improving the slowing down of nitrogen release.

The aim of the work was to increase the quality of the adduct granules and to develop an economical method of producing fertilizer with a slow release of nitrogen by coating the fertilizer granules with polymers.

Fig. 1. Photograph of the adduct obtained in the semi technical plant test in 2011

Fig. 2. Granulation unit of semi-pilot plant at Research Centre at Ł-INS

Semi-technical tests of NCaS fertilizer production and granulation were carried out in the granulation unit of Ł-INS (Fig. 2). The basic raw materials used were urea fertilizer (produced by G.A. Z.A. Puławy SA) and synthetic calcium sulphate hemihydrate from the flue gas desulfurization process with a grain size of less than 100 μm, (produced by Dolina Nidy Sp. z o.o.). A urea solution with a concentration of 80-90% by mass was sprayed onto the material in a granulation plate to which recycle and gypsum were continuously dosed at a temperature of approximately 55-65°C. Granules were produced in the granulation pan, fed into a drum dryer and, after classification on sieves, a granulated product (adduct) was obtained (Fig. 3).

Fig. 3. NCaS fertilizer granules obtained during a semi-technical test

Fig. 4. Laboratory unit for coating granulated fertilizers with a Teflon covered drum and an infrared radiator (150W)

The adduct granules were coated with Epidian epoxy resins (produced by Sarzyna Chemical Sp. z o.o.) using a laboratory coating unit (Fig. 4). The resin was applied to the granules in a rotating bed of material (Fig. 4) in 3 layers at a temperature of 80-90°C, maintained by irradiation with an infrared radiator. According to the new EU fertilizer Regulation 2019/1009, the fertilizer polymer coating should decompose by 90% in soil conditions within

4 years. Recent literature data indicate that epoxy polymers may be biodegradable with the participation of certain bacteria (Dutta et al., 2010; Eliaz et al., 2018), which gives hope for meeting these EU requirements.

The release rate of urea nitrogen from samples of fertilizer granulates was determined in the static tests by measuring the concentration of urea, by measuring the refractive index, in the solution that was in contact with the fertilizer sample at specific time intervals under conditions according to the methodology used in Japanese laboratories (Trenkel, 2010), (10 g of fertilizer / 200 g of water, differing slightly from those described in the EN 13266:2003 standard where 10 g of fertilizer / 500 ml of water is used).

Thanks to the use of the synthetic semi-aqueous gypsum (FGDG) and ground adduct recycling, the adduct granules were obtained with a spherical shape and a fairly smooth surface, which turned out to be useful for applying polymer coatings (Fig. 3). The NCaS granules were coated three times with Epidian epoxy resin in a total amount of 4% by mass. The time of applying and hardening of 3 layers of the coating did not exceed 50 minutes. The release time of 75% of nitrogen from this sample in the static test was approximately 90 days (Fig. 5).

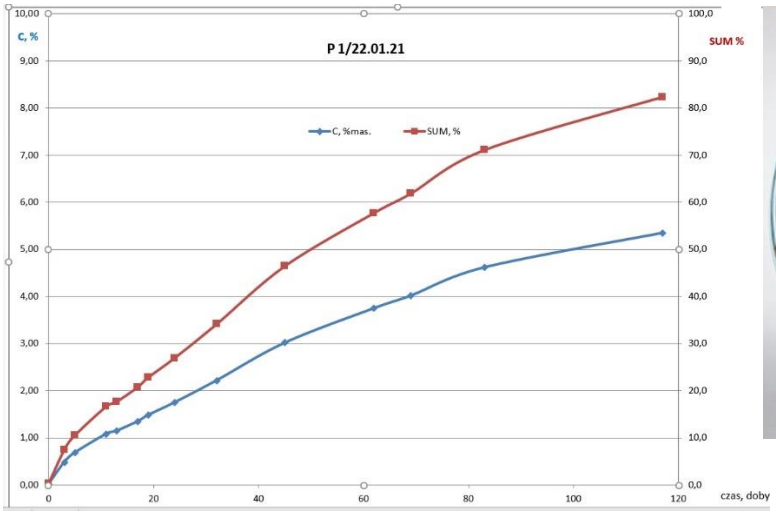

Fig. 5. % concentration (C) and urea release rate (SUM) from sample no. 1.22.01 (nitrogen release tests started immediately after the coating was made)

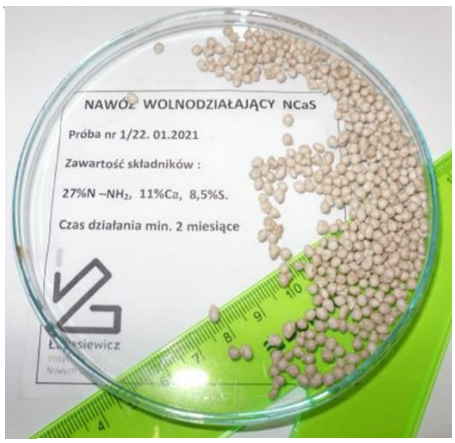

Fig.6. Photo - view of coated NCaS fertilizer granules

Conclusions

1. An economical method of production of granulated nitrogen-calcium-sulfur fertilizer with slow nitrogen release containing 27% N, 11% Ca, 8.5% S was developed. The fertilizer contains an adduct of urea and calcium sulfate and a polymer coating of epoxy resin in an amount of only 4% by mass.
2. The nitrogen release time is over 3 months, it can be adjusted according to the quantity/thickness of the coating.
3. Agricultural pot tests showed excellent effectiveness of the developed fertilizer, more than doubling the yield of rapeseed seeds.

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