MICRORADAR
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MICRORADAR-SERVICE LTD.
Pritickogo str, 62/4 of. 401,
Minsk, Belarus, 220140
Tel.: +(37517) 3631143, +375172014160
E-mail: market@microradar.com

www.microradar.com

Microradar-Service Ltd.
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On the measurement of water content in carbamide (urea) by microwave methods

Experiment by I.G. Kisialiou.

Director: I.I. Renhart

Abstract

We applied the microwave methods to measure the water content in carbamide (urea). The measured values of moisture were then compared with those obtained by drying technique. The results of our experiments proved the possibility of water content measurement in urea in the operational range of moisture.

Keywords

Water content, moisture, carbamide, urea, microwave method, resonator technique, transmission technique, granular materials, fertilizers.

Introduction

Carbamide (urea, chemical formula NH_2-CO-NH_2) is utilized mainly as a nitrogen-release fertilizer in agriculture. The measurement of its moisture is important for the material's quality control and for its proper storage.

Objective

The main goal of this work was to test the possibility of water content measurement for solid (granular) urea by microwave resonator or transmission technique, in the operational range of moisture.

Preparation of samples

The studied urea ("Pulrea", Poland) was supplied in the form of grains (1–4 mm). The material is nonhygroscopic in ordinary air conditions. The samples were prepared by exact wetting of initially-supplied material and kept for 40-hour retention. The water content of obtained samples was determined by a standard drying method (3 hours at 65 °C).

Method and instrumentation

We measured water content level in urea with the resonator-type laboratory moisture meter MR101-2. Each sample was deposited into the measuring cavity of resonator and corresponding Q-factor and frequency of the resonator mode were measured. These parameters were converted with a special algorithm into the density-independent invariant.

For the measurement in transmission geometry we applied the device MR113, working at the frequency of 40 GHz. The material was placed into a 75-mm length waveguide cavity. Samples' temperatures were equal to 17 °C.

Results

The results for resonator method application are demonstrated in Figures 1 and 2 In Figure 1, one can see the relation between the computed invariant M* and moisture W. In Figure 2, the values of actual moisture obtained by the standard method are compared with the moisture indicated by the laboratory device.

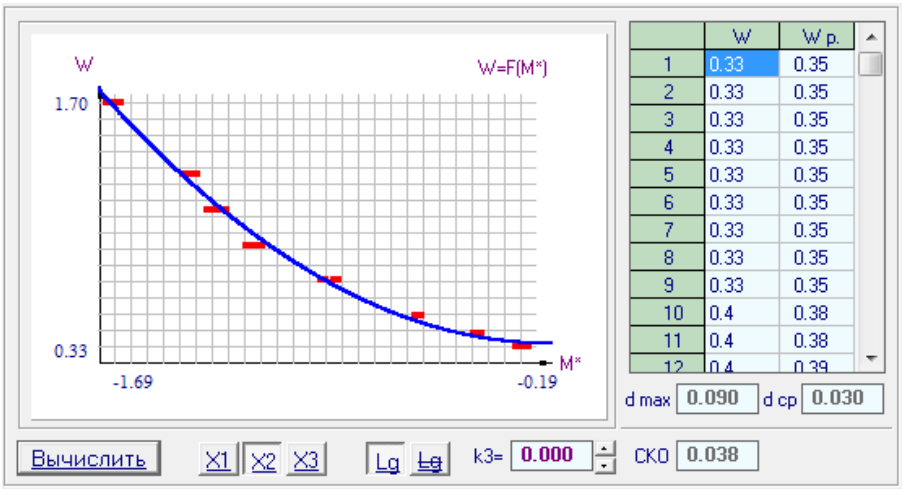

Figure 1. Relation between computed invariant and moisture

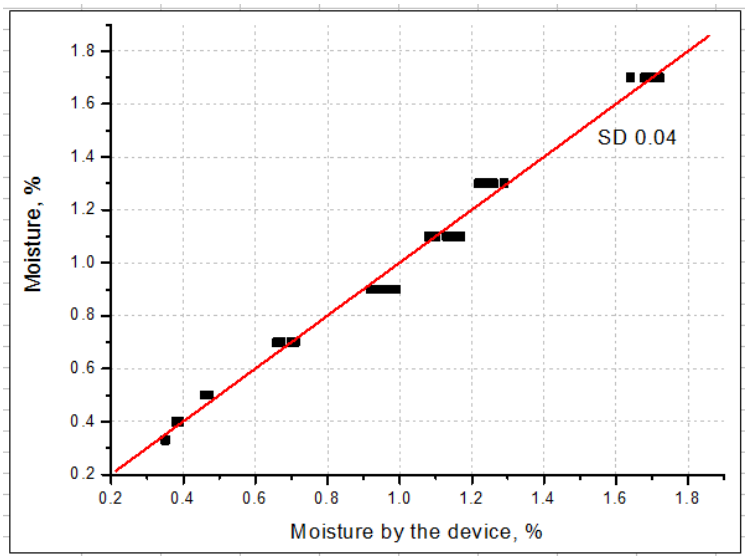

Figure 2. Moisture values obtained by standard method against the moisture indicated by the instrument

In addition, we've made a successful attempt to apply transmission method at the frequency of 40 GHz. The result of approximation for experimental data is shown in the Figure 3 below.

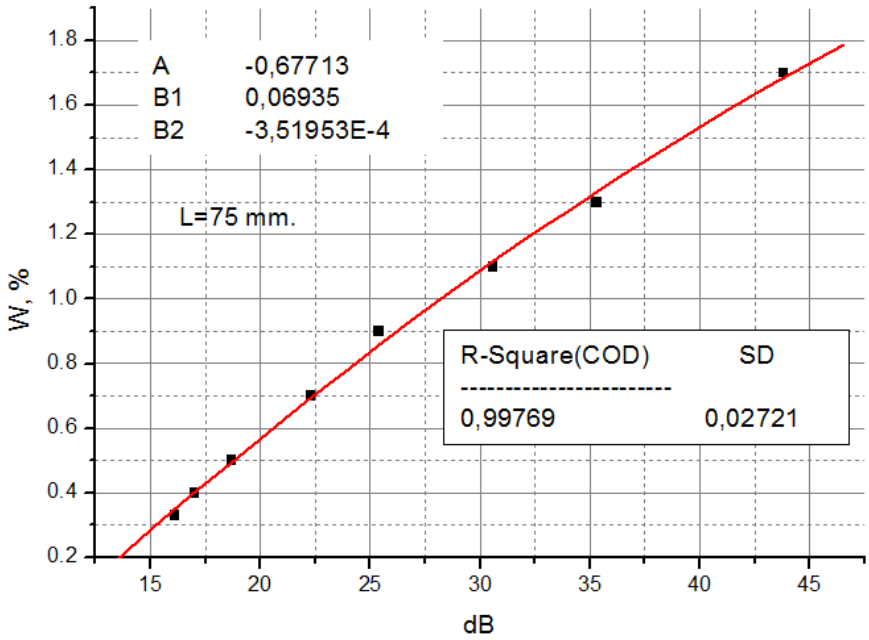

Figure 3. Moisture values by standard method against the attenuation at 40 GHz, indicated by the instrument

Conclusion

As it comes from our study, the resonator microwave technique at frequency 2.5 GHz is able to provide the measurement of water content in granular carbamide (urea) in the range of 0.3–1.7% with accuracy at least 0.05 % (SD).

The same positive statement is applied to the microwave transmission method at the 40 GHz frequency.

However, it is necessary to take into account that the experiments were conducted over the single material, so that variations in material composition can affect the accuracy of measurement under actual industrial conditions.