IR SPECTRAL ANALYSES OF CALCIUM NITRATE BASED ON ZARBANT MARBLE

T.T.OTAKUZIYEV

SH.S.NAMAZOV

A.A.MAMATALIYEV

General and Inorganic Chemistry Institute

of the Academy Sciences of the Republic of Uzbekistan

stosds98@gmail.com

Annotatsiya: To determine the nature of the interaction between the additives and calcium nitrate — specifically, whether a new chemical compound is formed between them or whether the bonding is solely of a physical-mechanical character the most representative sample from each of the three groups was selected and subjected to infrared (IR) spectroscopic analysis: phosphogypsum as an inorganic waste additive (at a ratio of 100:4), Zarbant marble powder as a natural carbonate additive (at a ratio of 100:5), and sodium carboxymethyl cellulose as an organic polymer additive (at a ratio of 100:0.6). The spectra were recorded in the transmission mode over the wavenumber range of 400–4000 cm^{-1}; the results are presented in Figures 1–3.

Keywords: IR spectrum, calcium nitrate, Na-CMC, phosphogypsum, Zarbant marble

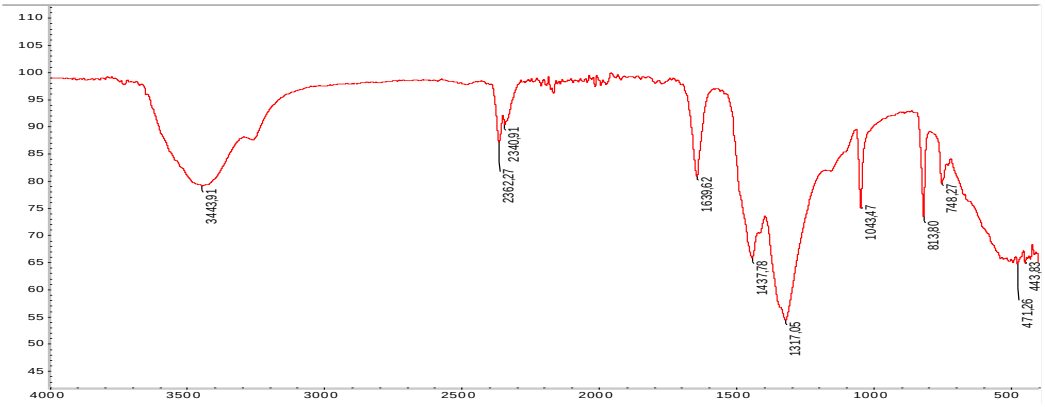

Fig. 1.IR spectrum of a granular calcium nitrate sample with phosphogypsum additive (at a ratio of 100:4).

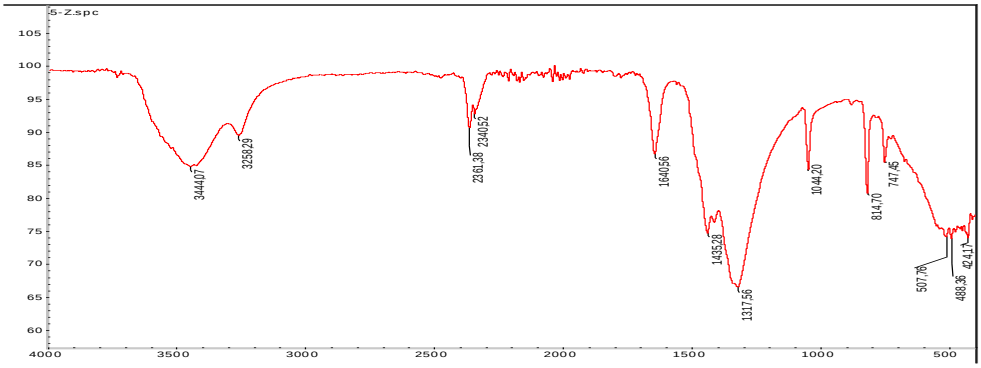

Fig. 2.IR spectrum of a granular calcium nitrate sample with Zarbant marble additive (at a ratio of 100:5).

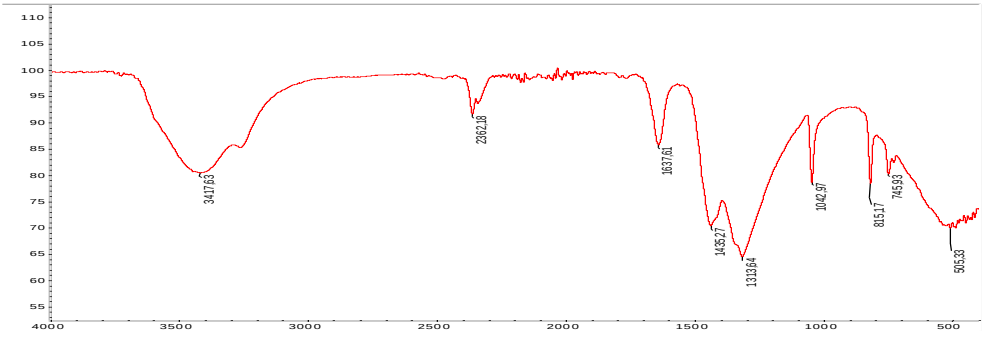

Fig. 3. IR spectrum of a granular calcium nitrate sample with Na-CMC additive (at a ratio of 100:0.6).

The overall spectral structure of all three samples is characteristic of calcium nitrate crystallohydrate. Two main groups of bands are observed:

Water of crystallization**:** stretching at ~3417–3444 cm^{-1} and bending at ~1637–1641 cm^{-1} – both high-intensity, confirming bound crystallohydrate water.

Nitrate ion: free nitrate (D_{3h} symmetry) shows a single ν_3 band near 1380 cm^{-1}, but in all samples ν_3 splits into two components (1435–1438 and 1314–1318 cm^{-1}), and ν_1 appears at ~1043–1044 cm^{-1} – indicating reduced nitrate symmetry ($D_{3h} \rightarrow C_{2v}$) and coordination bonding to Ca^{2+}.

Key result: All major nitrate bands remain virtually unchanged across the three samples (differences only 1.23–2.34 cm^{-1}, within instrument resolution), and no new absorption bands appear. This proves that no chemical reaction occurs between calcium nitrate and any of the additives – the additives are distributed as independent phases.

Additive-specific differences:

Zarbant marble (carbonate): an additional low-frequency O–H component (3258 cm^{-1}) appears, indicating strongly hydrogen-bonded water on particle surfaces; the smallest ν_3 splitting (117.72 cm^{-1}) means minimal distortion of nitrate ions. This confirms marble acts as an inert filler – strength increase (from 1.98 to 5.31 MPa) is purely due to pore filling and crack arresting.

Na-CMC (polymer): O–H band shifts ~26–27 cm^{-1} to lower frequencies; the largest ν_3 splitting (121.63 cm^{-1}); ν_1, ν_3, and ν_4 bands shift by 1.2–3.9 cm^{-1}. These features collectively indicate coordinative interaction between carboxylate groups of the polymer and Ca^{2+} ions, forming a continuous polymer network within the granule – explaining why only 0.6% Na-CMC increases strength by 1.34 times.

Conclusion: Two distinct mechanisms are at work – inorganic additives act as inert fillers (mechanical reinforcement), while the organic polymer

forms chemical coordination bonds with Ca^{2+}. Their combined use (marble + Na-CMC) is a promising route for further product quality improvement.

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