

ENVIRONMENTAL AGEING OF BASIC COPPER NITRATE

Characterizing the Effects of Temperature and Humidity on the Physical Properties of BCN

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BASIC COPPER NITRATE

In the world's leading pyrotechnic airbag technology, a rapid reaction between Basic Copper Nitrate (BCN, $\text{Cu}_2(\text{OH})_3(\text{NO}_3)$) and guanidine nitrate produces nitrogen gas, which inflates the airbag—producing life-saving results. Like most inorganic materials, BCN particles will coarsen when exposed to temperature and humidity over time. However, there is a lack of information available characterizing the impact of this coarsening process of BCN particles. The results herein provide a framework for understanding how humidity and temperature affects the physical properties of BCN, and specifically surface area. Finally, we present preliminary results on how packaging and changes in particle preparation can permit BCN material to resist ageing.

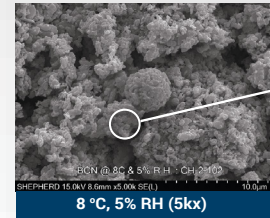
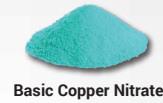
ACCELERATED BCN AGEING MODEL

A recently manufactured lot of BCN was aged for 5 days under a range of temperature (8-85 °C) and relative humidity (5-95% RH) conditions and analyzed using BET and SEM.

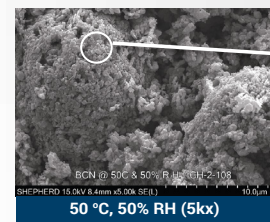
Changes in Surface Area with Ageing* (m ² /g)					
Relative Humidity	8 °C	25 °C	50 °C	65 °C	85 °C
95%	3.28	2.55	2.60	2.05	
75%		2.83	2.26	2.06	1.90
50%	4.15	3.87	3.16	2.99	2.18
25%		4.22	4.18	4.00	
5%	4.56		4.54		4.10

*Data points were calculated by averaging the measurements of 5 independent samples.

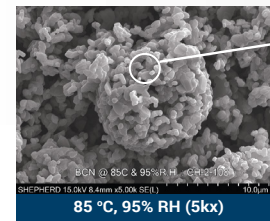
BCN PARTICLE COARSENING



S.A. = 4.70 m²/g
Primary particle size* = 0.04 μm



S.A. = 4.11 m²/g
Primary particle size* = 0.07 μm

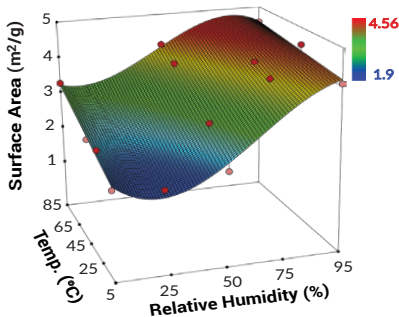


S.A. = 2.06 m²/g
Primary particle size* = 0.50 μm

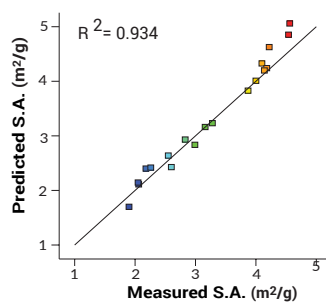
*Determined by averaging the area of 10 particles within the 30kx screen using imageJ



3D Surface Area vs. Temp. & Humidity



Predicted vs. Measured Surface Area



The measured dependence of surface area on temperature (T) and relative humidity (H) can be modeled using the expression below.

$$\text{Surface Area} = 3.24 - 1.81(H) - 0.84(T) - 0.18(HT) + 0.30(H^2) + 0.47(H^2T) + 0.96(H^3)$$

AGEING OF RELATED MATERIALS

Ageing of BCN was compared to ammonium nitrate (NH_4NO_3), copper nitrate crystals ($\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$), and copper oxide (CuO) under similar conditions. Samples of ammonium nitrate and copper nitrate crystals dissolved above 50 °C and 50% RH due to deliquescence and higher solubility.

Copper Oxide	Ammonium Nitrate	Copper Nitrate Crystals
Solubility: Insoluble	Solubility: 297 g/100 mL at 40 °C	Solubility: 381 g/100 mL at 40 °C

*suitable SEMs could not be taken at other conditions

↓ **30%** Decrease in Surface Area



IT DISSOLVES!



IT DISSOLVES!

PACKAGING SOLUTIONS

To improve surface area stability, we evaluated 3 different packaging options on the relative time that manufactured BCN would remain within specification when stored in a warehouse without climate control.

2X Longer

>3X Longer



Single-Lined Box

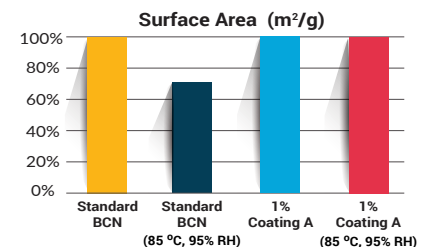
Double-Lined Box

Liquid-Lined Bulk Bag

Increasing Surface Area Stability

AGE-RESISTANT BCN

Particle coarsening can also be inhibited by particle surface modification. Using the accelerated ageing method, we evaluated samples of BCN with low levels of various coatings.



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