

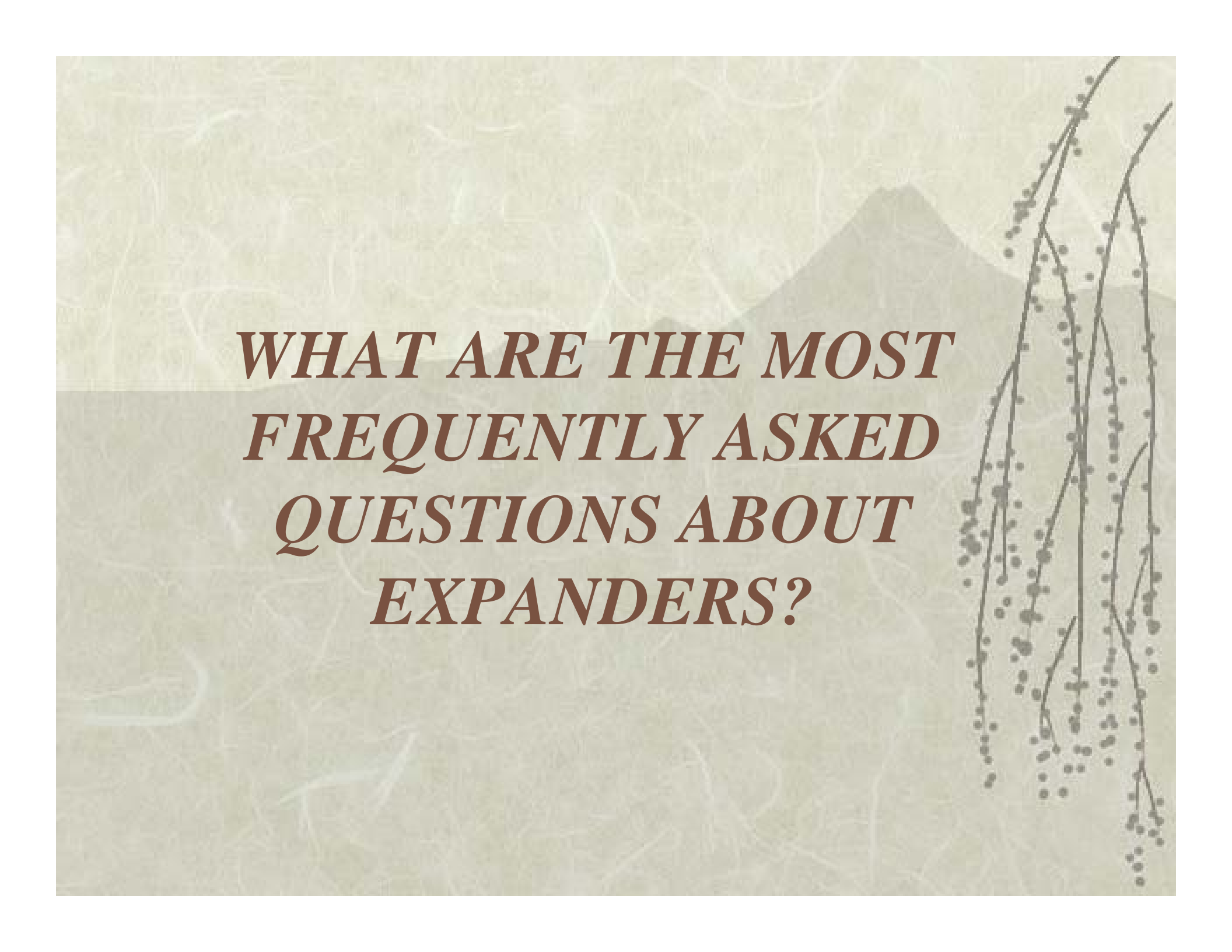


**9<sup>th</sup> ASIAN BATTERY CONFERENCE**  
**BALI, INDONESIA**  
**SEPTEMBER, 2001**

David P. Boden

Hammond Expanders

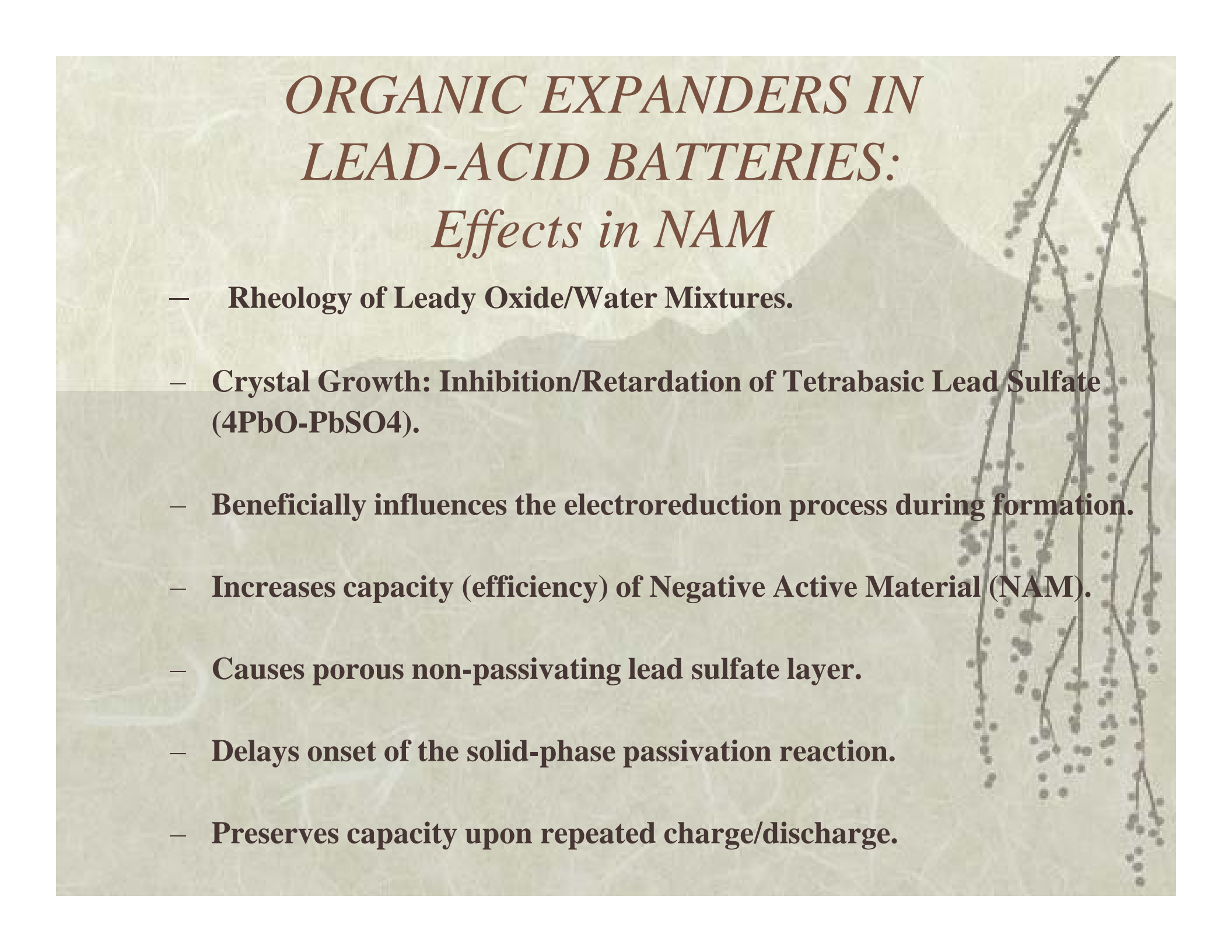
Division of Hammond Group, Inc.



***WHAT ARE THE MOST  
FREQUENTLY ASKED  
QUESTIONS ABOUT  
EXPANDERS?***

The background features a stylized, muted landscape. In the upper half, there are silhouettes of mountain peaks against a light, textured background. In the lower half, a dark, textured foreground is visible. On the right side, a branch of a willow tree hangs down, adorned with small, dark, round buds or leaves. The overall color palette is earthy and monochromatic, consisting of various shades of beige, tan, and brown.

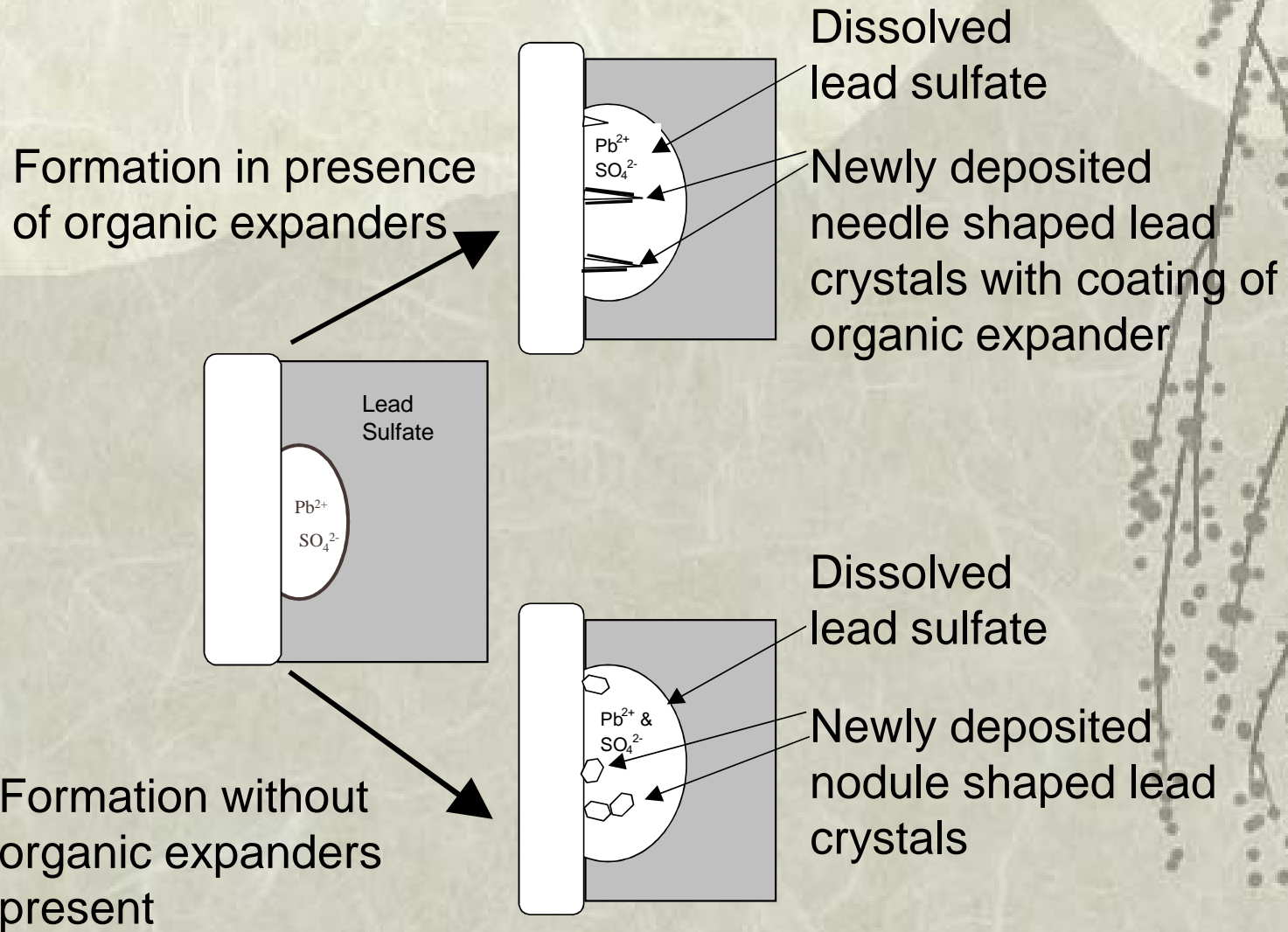
***HOW DO  
LIGNOSULFONATES WORK?***



*ORGANIC EXPANDERS IN  
LEAD-ACID BATTERIES:  
Effects in NAM*

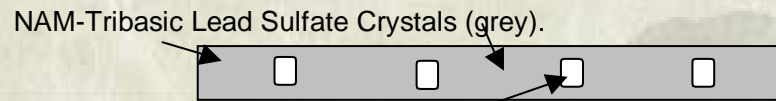
- **Rheology of Lead Oxide/Water Mixtures.**
- **Crystal Growth: Inhibition/Retardation of Tetrabasic Lead Sulfate ( $4\text{PbO}\cdot\text{PbSO}_4$ ).**
- **Beneficially influences the electroreduction process during formation.**
- **Increases capacity (efficiency) of Negative Active Material (NAM).**
- **Causes porous non-passivating lead sulfate layer.**
- **Delays onset of the solid-phase passivation reaction.**
- **Preserves capacity upon repeated charge/discharge.**

# ***DISSOLUTION/DEPOSITION THEORY***

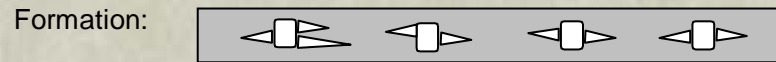


# *Cross-Sectional Diagram of Pasted Plate and Morphology Changes During Formation w/ and w/o Organic Expander.*

With Organic Expander:



Metallic Lead Alloy Grid Structure.



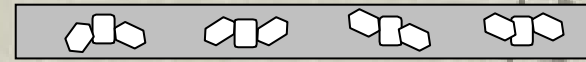
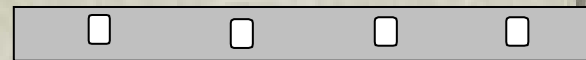
Needle shaped lead crystals grow perpendicular from grid surface. This shape yields very high surface to volume ratio.



Secondary crystals form perpendicular to primary crystals. Spongy porous lead is the result of the density difference between high density lead and low density tribasic lead sulfate. The latter is about half the former.

The formed negative plate has 3x to 5x more surface area with organic expands than without.

Without Organic Expander.

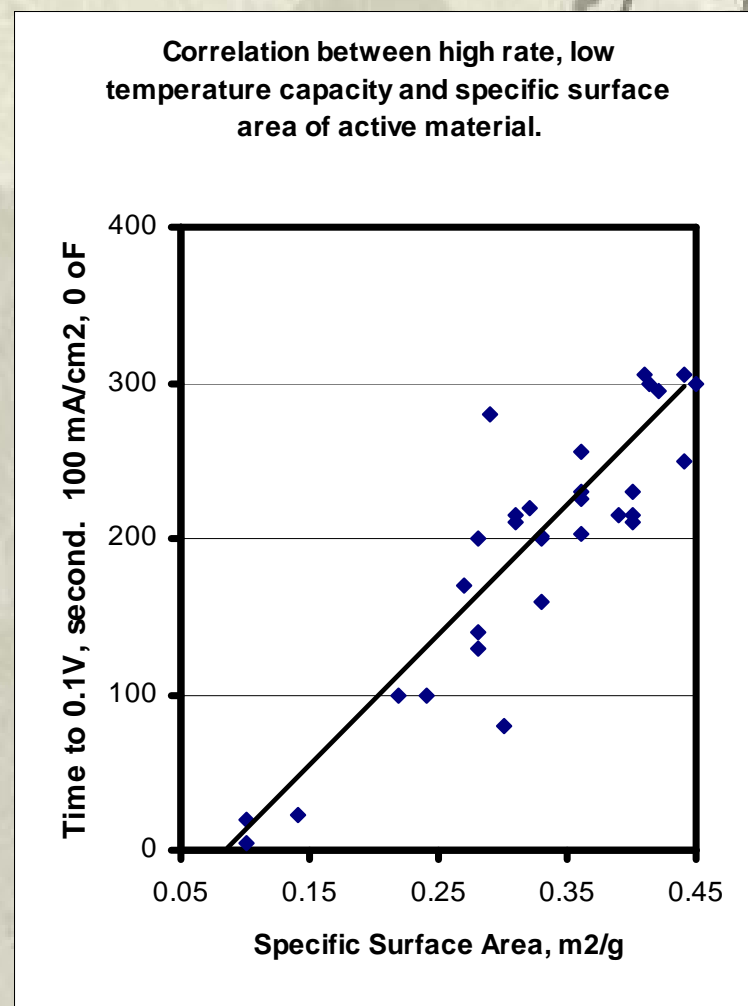


Coarse noduls form in place of narrow needle crystals. This shape yields lower surface area to volume ratio.

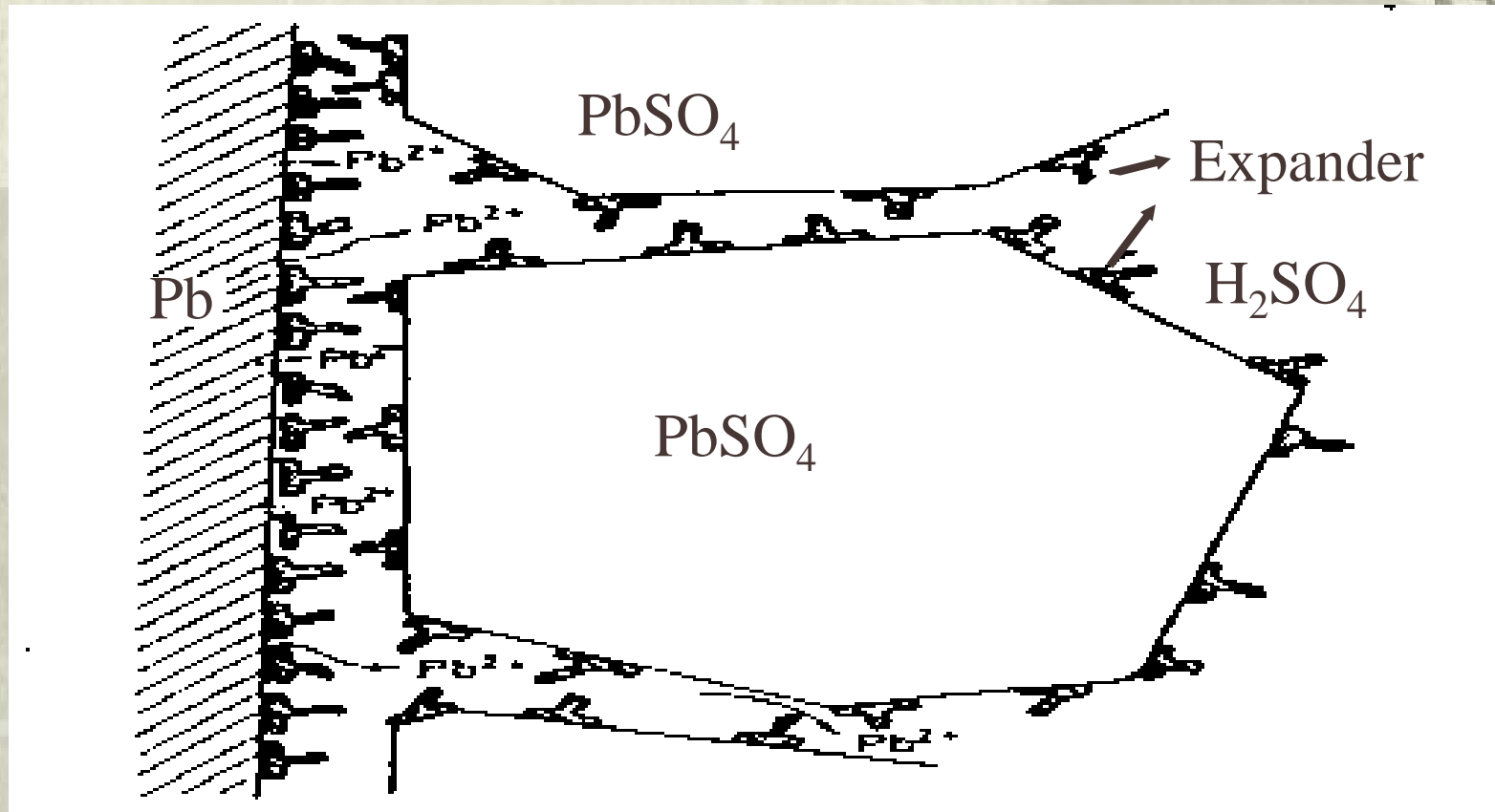


# *Relationship Between Surface Area and High Rate/Cold Discharge (Mahato)*

- ❖ There appears to be linear relationship between high rate/cold discharge capacity and the BET-nitrogen adsorption surface area.
- ❖ With increase in surface area, more electrolyte is in contact with lead metal. Hence the current per unit area of electrode is lower.
- ❖ Increases the available reactive mass and area of lead.
- ❖ Hence a higher rate or longer duration of high rate discharge can be achieved.
- ❖ Capacity is less limited by the ability of electrolyte to diffuse into the electrode.
- ❖ The cold capacity of plates with 0.5% organic is 2x to 3x plates without.



*Artists perspective of lignosulfonate adsorbed onto lead and lead sulfate after discharge. (Myrvold)*



# *Correlation Between Structure of Lignosulfonates and the Effect on Capacity and Life (Myrvold)*

## ❖ Functional Group

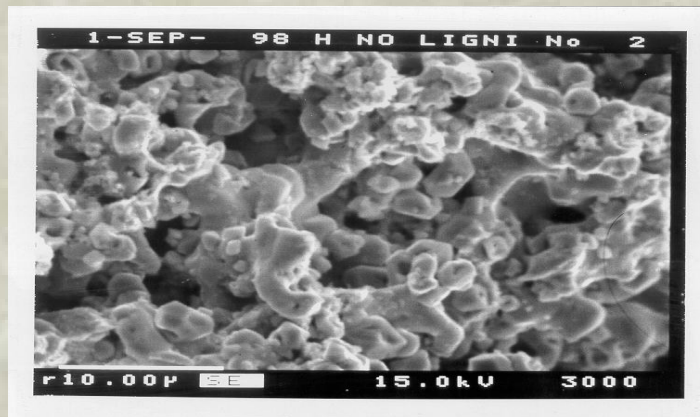
- ❖ Phenolic OH
- ❖ Carboxyl
- ❖ Methoxyl
- ❖ Phenolic Hydroxy
- ❖ Organic Sulfur
- ❖ Molecular Weight
- ❖ Metals

## ❖ Effect

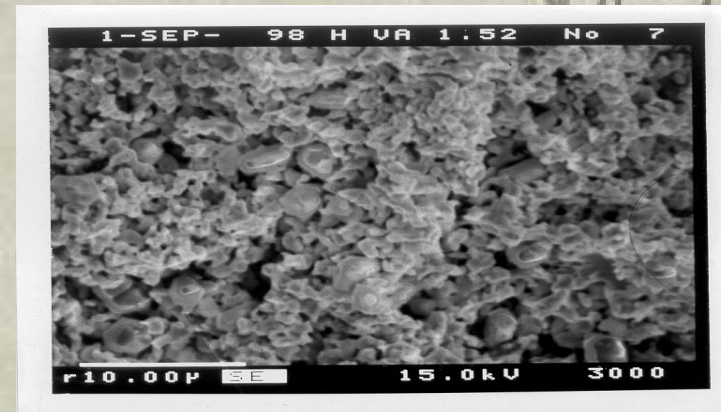
- ❖ Beneficially influences cycle life, possible weak negative effect on initial performance.
- ❖ Positive correlation with capacity, suggests oxy lignins are better.
- ❖ Positive correlation with CCA, suggests purer is better.
- ❖ Weak negative correlation with charge acceptance.
- ❖ Negative correlation with initial performance. No discernable relationship with life.
- ❖ Negative correlation with initial. No discernable relationship with life.
- ❖ No negative correlation was found.

# ***ORGANICS***

- ❖ Adsorb on the surface of the lead crystals
- ❖ Increase the surface area of active material
  - From 0.2 sq. m./g to 0.8 sq. m./g
- ❖ Produce fine, porous crystal structure
- ❖ Improve low temperature capacity

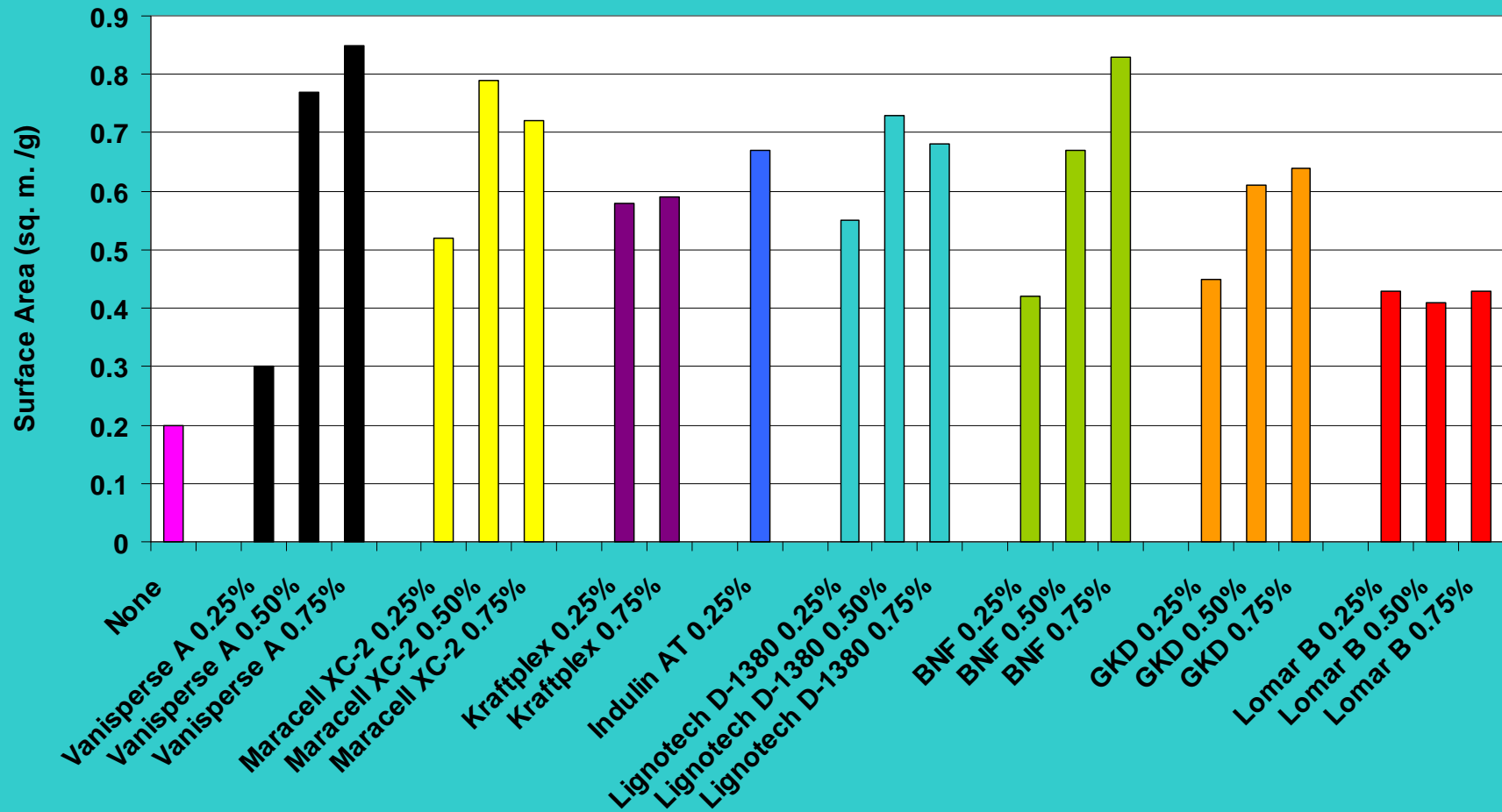


No Organic

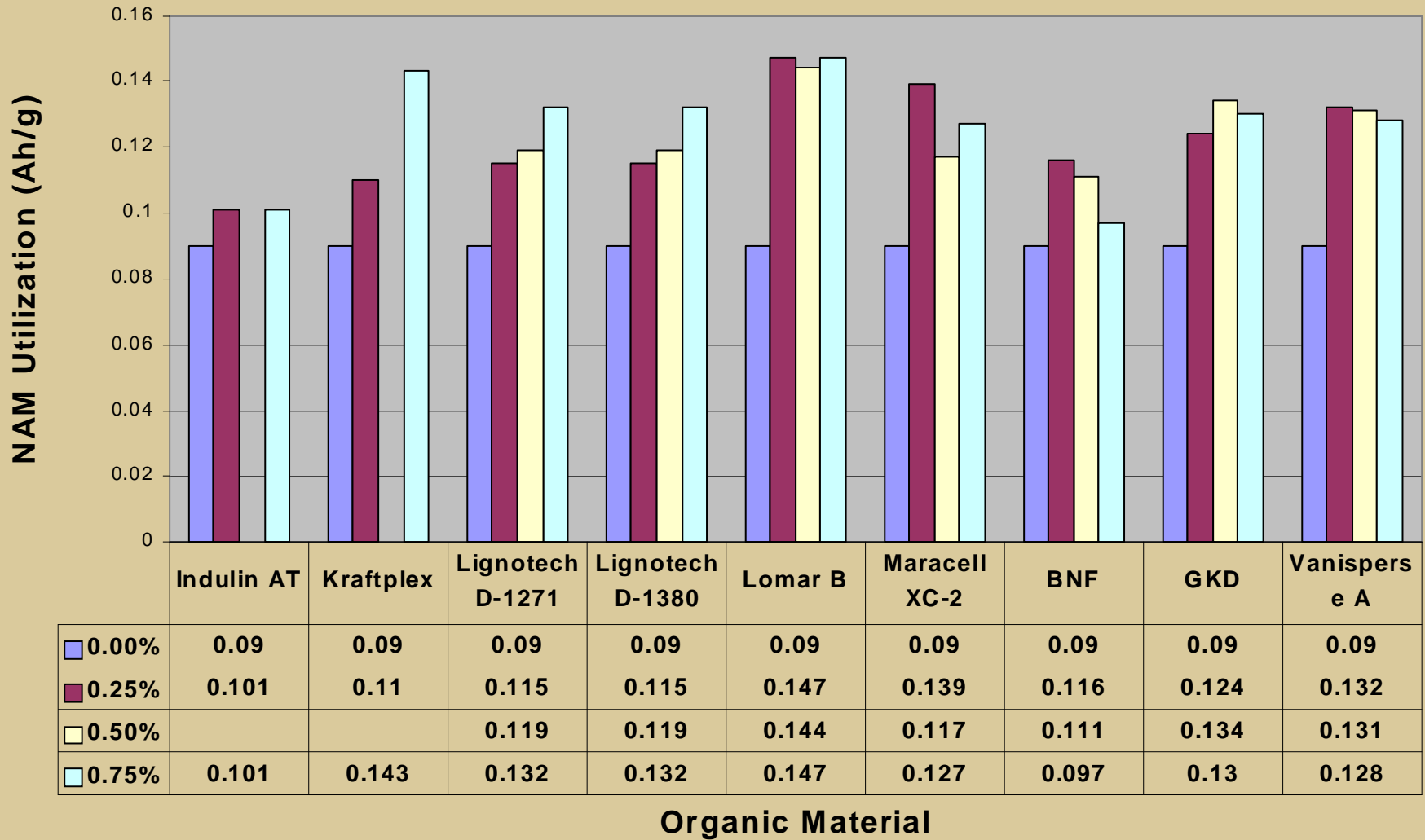


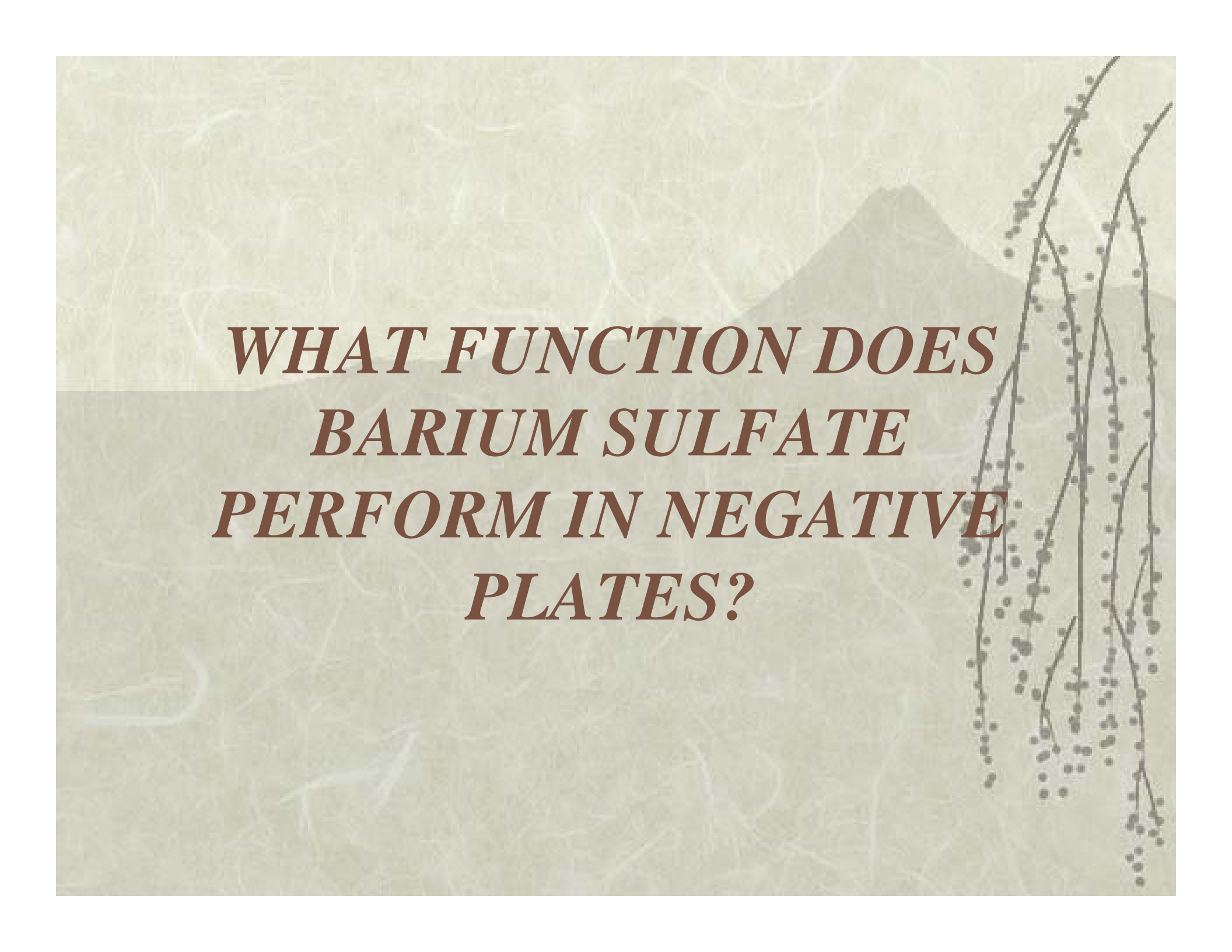
0.5% Vanisperse A

## BET Surface Area of Formed Negative Active Material With Various Organic Additives



## Negative Active Material Utilization (Ah/g) at 5-Hr Rate





***WHAT FUNCTION DOES  
BARIUM SULFATE  
PERFORM IN NEGATIVE  
PLATES?***

# ***BARIUM SULFATE***

- Two types are used

- **Blanc Fixe**

- Precipitated from solution**

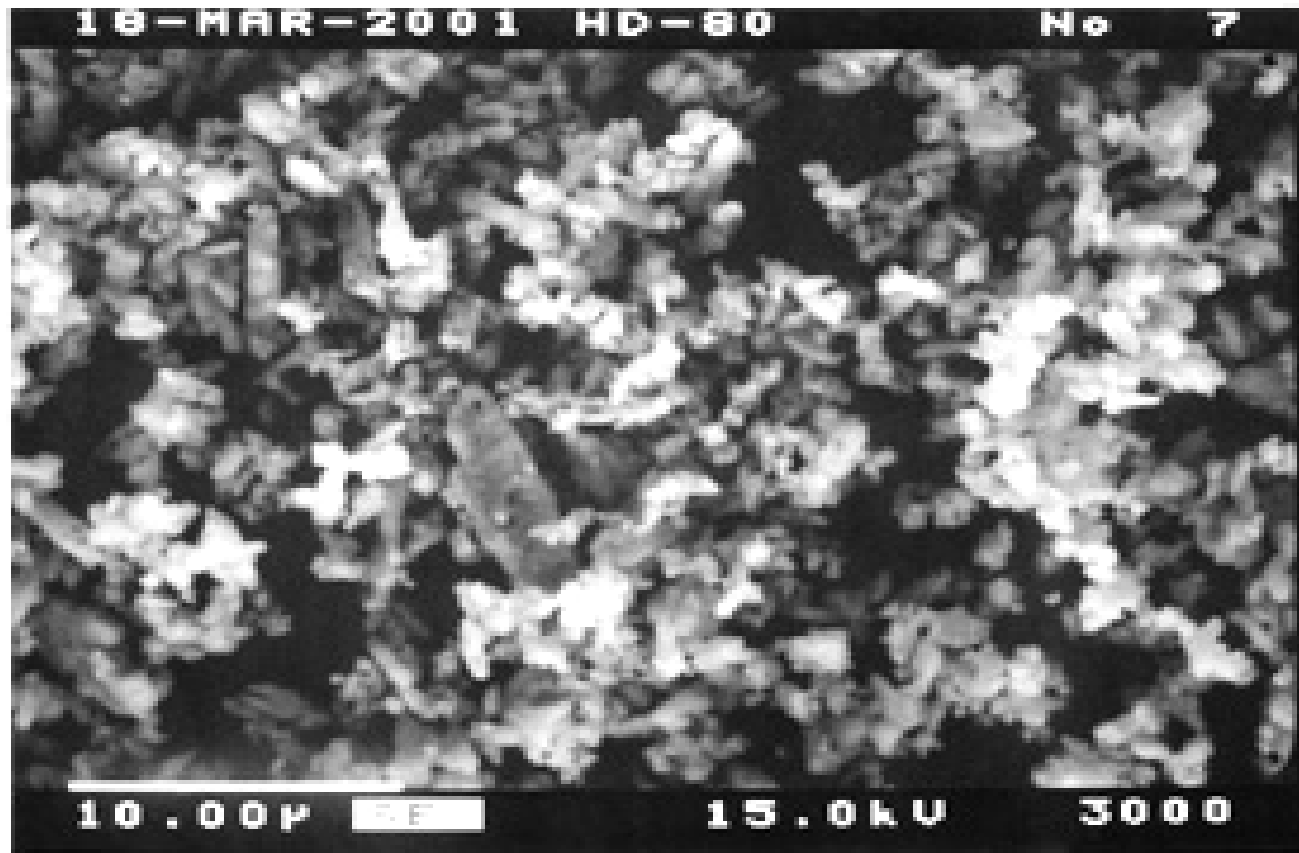
- Median particle size =  $1.0 \pm 0.25$   
microns**

- **Barytes**

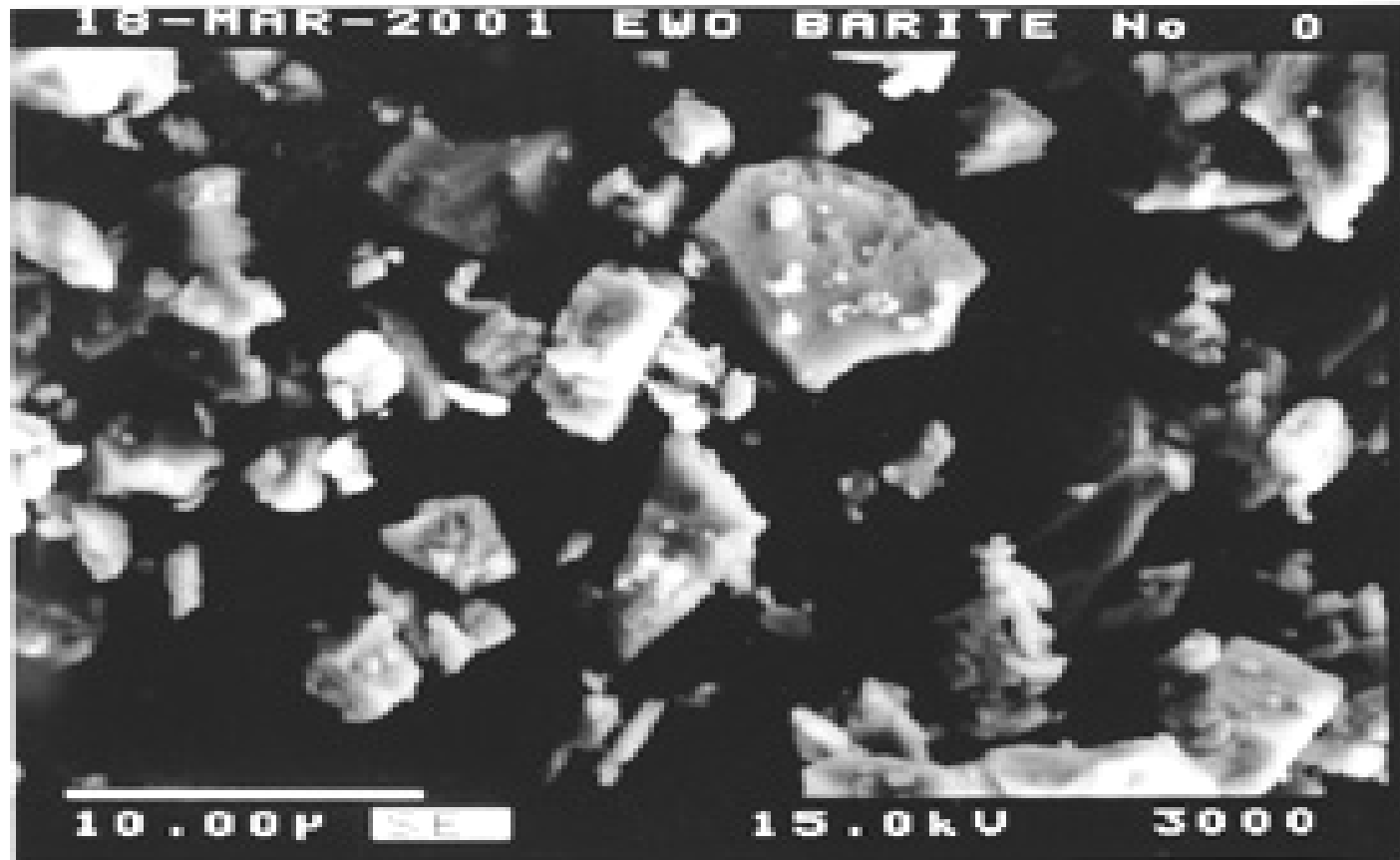
- Milled mineral**

- Median particle size =  $3.5 \pm 0.5$   
microns**

# *SEM IMAGE OF BLANC FIXE*



# *SEM IMAGE OF BARYTES*



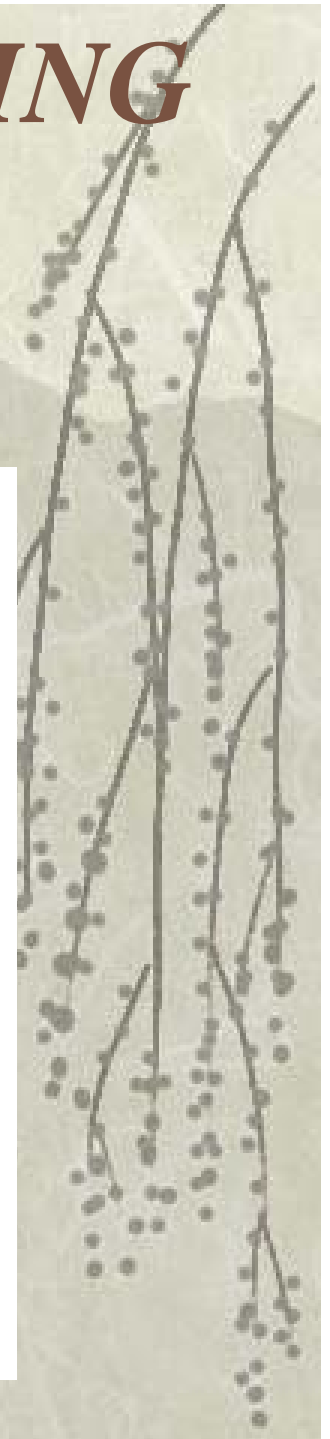
# ***FUNCTION OF BARIUM SULFATE***

- Prevents passivation of the active material by lead sulfate**
  - Barium sulfate and lead sulfate have almost identical crystal structures
  - Lead sulfate precipitates on the barium sulfate crystallites – this eliminates “coating” of the lead sponge
  - (*Energy of crystallization is eliminated, making it easier for the lead sulfate to grow on the barium sulfate crystals than on the lead*)

# *STRUCTURAL CHARACTERISTICS OF BARIUM AND LEAD SULFATES*

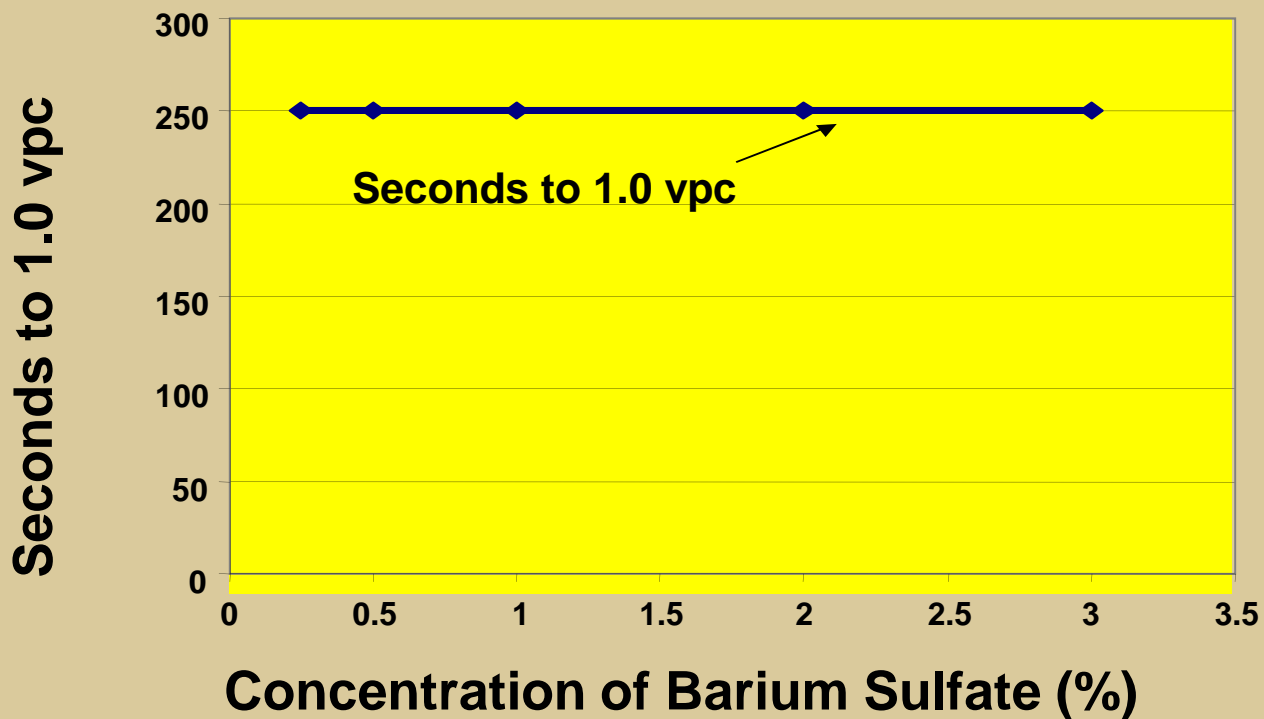
	<b>BaSO<sub>4</sub></b>	<b>PbSO<sub>4</sub></b>
<b>Cation-O bond length (Å)</b>	<b>2.952</b>	<b>2.87</b>
<b>S-O bond length (Å)</b>	<b>1.478</b>	<b>1.490</b>

*LEAD SULFATE NUCLEATING  
ON BARIUM SULFATE  
PARTICLES*

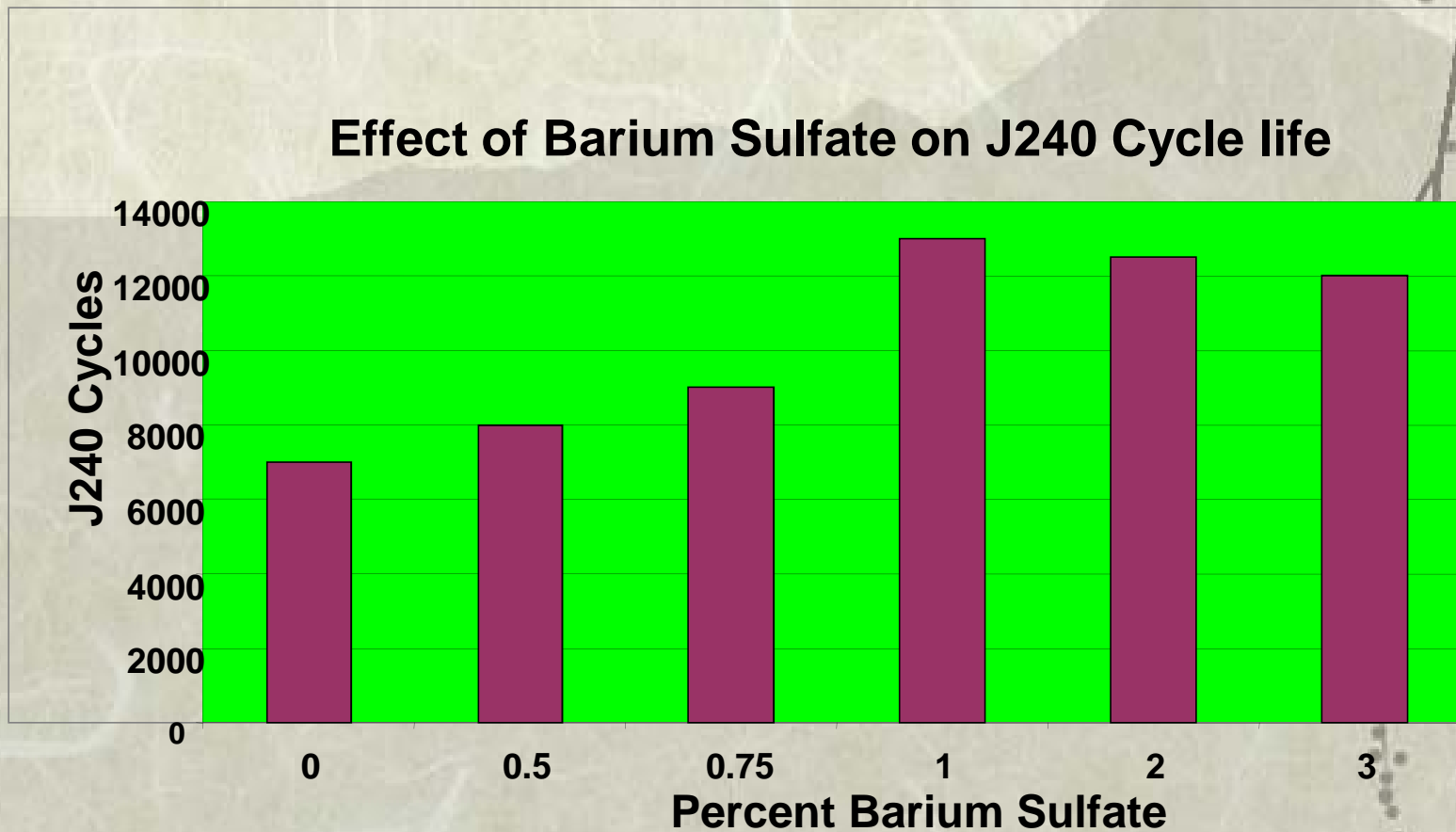


# ***BARIUM SULFATE DOES NOT IMPROVE COLD CRANKING PERFORMANCE***

**Effect of Barium Sulfate on Cold Cranking Performance**

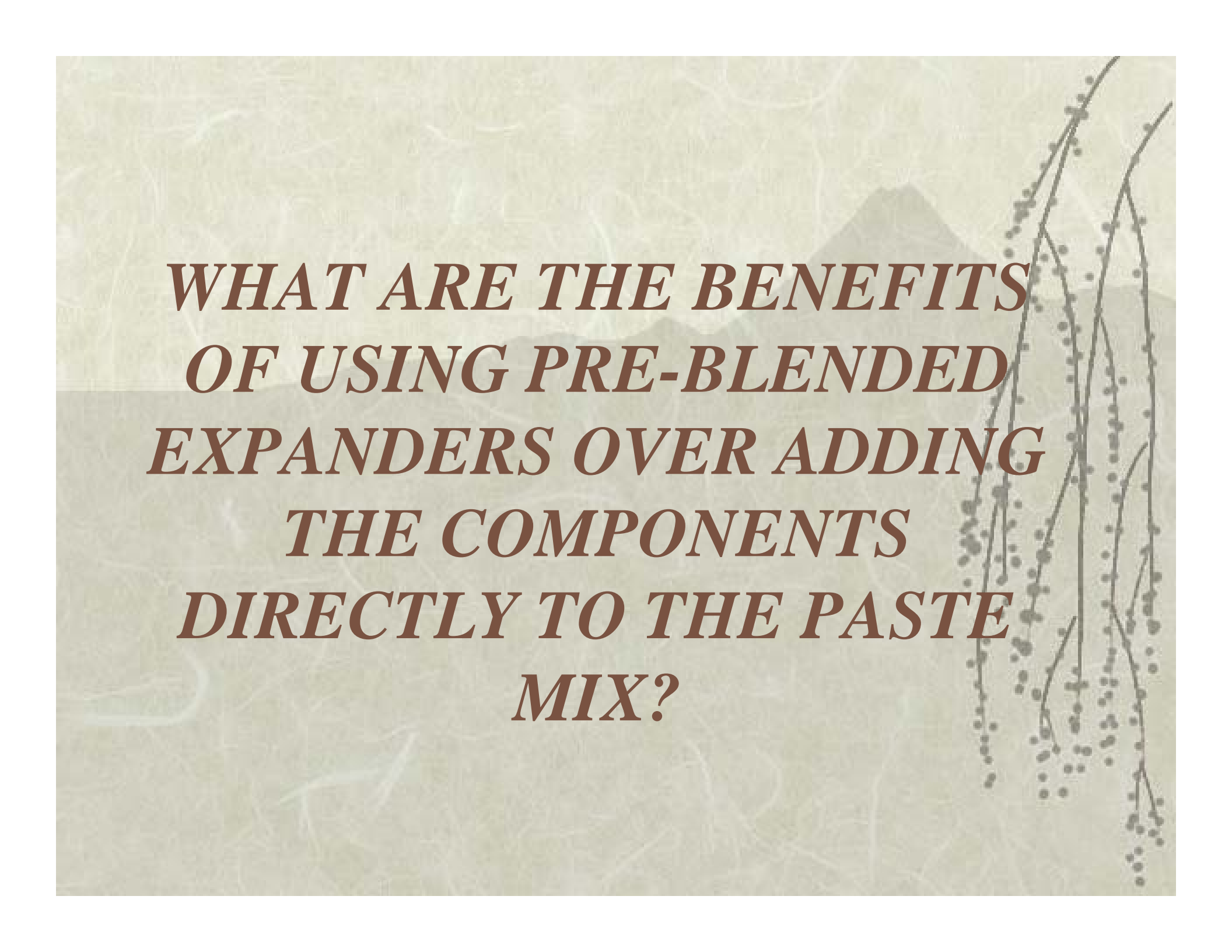


# ***BARIUM SULFATE DOES IMPROVE CYCLE LIFE***



# ***FUNCTION OF BARIUM SULFATE***

- Barytes is only used in industrial battery expanders
  - Originally added to improve flow and dispersion
  - But!
    - May act as slow release agent**

The background features a soft-focus landscape with a mountain range under a pale sky. In the foreground, several thin, dark branches of a willow tree hang down, adorned with small, dark buds. The overall color palette is muted and naturalistic, with shades of beige, light green, and brown.

***WHAT ARE THE BENEFITS  
OF USING PRE-BLENDED  
EXPANDERS OVER ADDING  
THE COMPONENTS  
DIRECTLY TO THE PASTE  
MIX?***

# ***BENEFITS OF PRE-BLENDED EXPANDER***

## ❖ **Lower cost**

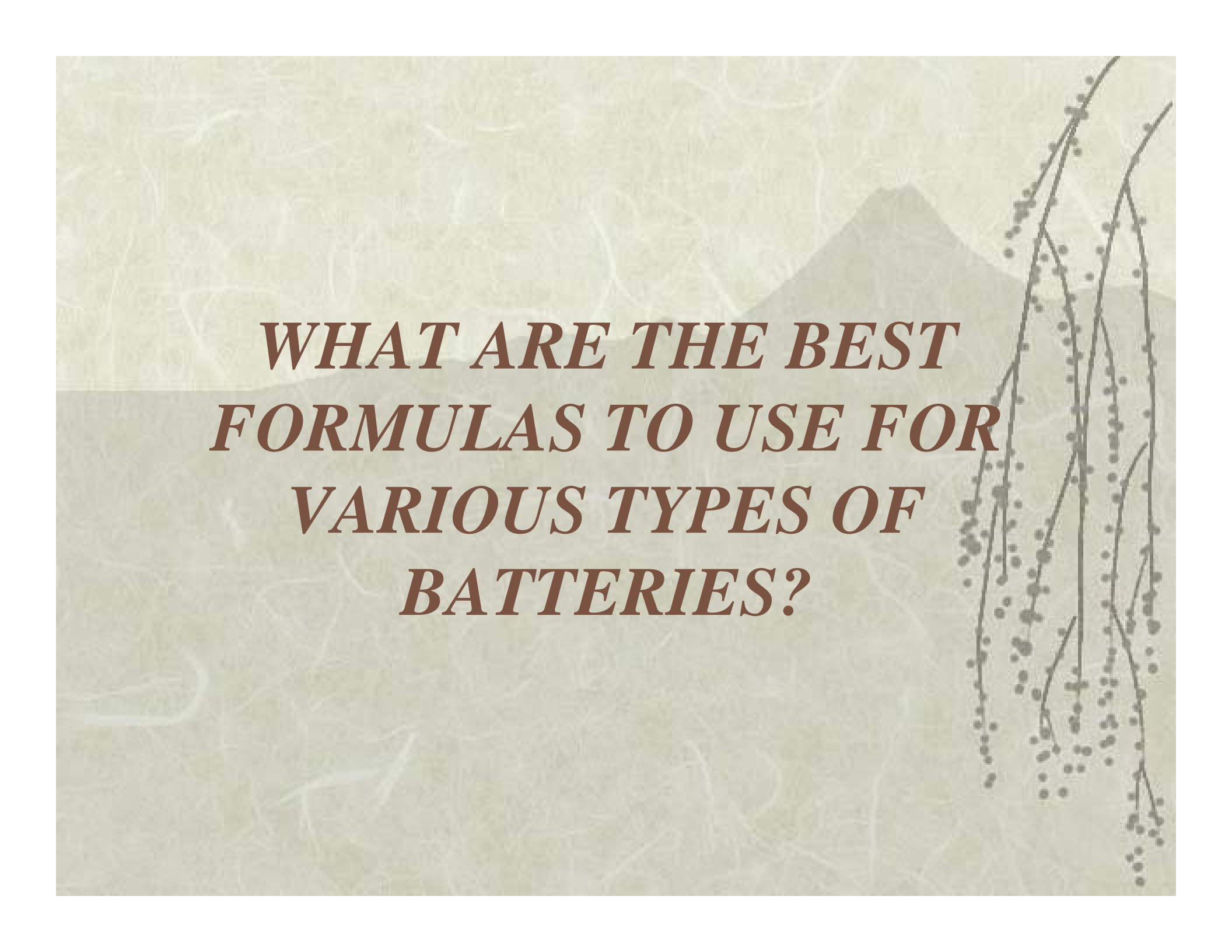
- **Eliminates labor**
- **Eliminates equipment**
- **Reduces material cost**
- **Reduces inventory cost and storage space**
- **Reduces paperwork**

❖ **Expander is tested before it goes into the battery**

❖ **Bag weights exactly match your paste batch**

❖ **Elimination of paste mixing errors**

❖ **Proven formulas**



***WHAT ARE THE BEST  
FORMULAS TO USE FOR  
VARIOUS TYPES OF  
BATTERIES?***

# *APPLICATIONS GUIDE*

<b>Application</b>	<b>Recommended Types</b>			
<b>Automotive</b>	<b>HE-4640</b>	<b>HE-631</b>		
<b>Motive Power</b>	<b>HE-115</b>	<b>HE-120</b>	<b>HE-1511</b>	
<b>Telecommunications</b>	<b>HE-750</b>	<b>HE-KXLF</b>		
<b>UPS</b>	<b>HE-1160</b>			
<b>Valve Regulated</b>	<b>HE-120</b>	<b>HE-150</b>	<b>HE-1160</b>	<b>HE-KXLF</b>

# *Acknowledgement*

- ❖ Mr. Timothy McNally, Lignotech USA

**HAMMOND**

**EXPANDERS**<sup>TM</sup>

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