Abstract: Molecular Rebar™ in Lead Acid Batteries

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Lead acid batteries are made in two main types, namely, Flooded and Valve Regulated Lead Acid (VRLA), and are used in the following primary application areas:

1) Micro-hybrid applications
2) Automotive applications
3) Telecom and UPS applications
4) Traction applications

Although the applications/designs are widely different, recent analysis by various research groups and battery companies proved that **failure modes are more or less same, due to over usage in combination with under charging of batteries in all the applications**. The most common failure modes are:

1) Sulphation of negative plate
2) Acid Stratification

For the past two decades, the problem is being approached by using **high quantity (2% w.r.t. dry oxide)** of specialized carbons in negative paste. The types of carbon currently used for negative paste are:

1) Carbon black of nanometer particle range
2) Activated carbon
3) Graphite
4) Combination of carbon black and graphite

There are several claims by various groups yet there is no consensus to date about the type and quantity of carbon to be used in the paste. At the same time, there are several theories proposed to explain the mechanism of carbon action. They are:

1) Increase in conductivity of the paste by carbon
2) Steric hindrance resulting in in changing the crystal size by carbon
3) Role of carbon in changing the pore size
4) Electro catalytic effect of carbon in assisting the lead deposit reaction
5) Role of Carbon acts as a capacitor
6) Effect of carbon on hydrogen evolution reaction

Though the literature claimed that **some forms of carbon improved charge acceptance of batteries in micro hybrid application, regarding other applications it is somewhat silent**.

There are also research papers that discuss the negative impact of these additives on:

1) Paste density
2) Difficulty encountered in pasting, requiring new pasting machine / process
3) Open circuit voltage decay of carbon enhanced batteries in the field
4) Effect of carbon in cold cranking performance
5) Effect of carbon on reserve and C-20 capacity
6) Effect of carbon on initial charging

Since the above **carbon particle additives in negative paste are leading to significant manufacturing and performance related problems**, a radically new approach is needed to make this concept very successful. The approach should consider the following boundary conditions:

1) It should not change paste density. Additive percentage should be below 0.2%
2) It should be able to run with existing machinery, such as, conventional belt pasting machines
3) It should not increase the charging time of batteries, which in turn affect plant throughput
4) It should not reduce RC and C-20
5) It should not reduce cold cranking performance in the case of automotive batteries
6) It should not increase open circuit voltage decay
7) It should have very good charge acceptance, both at short and long time application.

The preliminary studies prove that, **Molecular Rebar™, functionalized discrete carbon nanotubes, dispersed in a special surfactant is ideal for negative paste**. **At a very low percentage, it does not alter paste density, it disperses well in the paste and it can be pasted using conventional belt pasting machine without any difficulty.**

After identifying Molecular Rebar™ integrated with a specific surfactant, batteries were made and tested for various industry standard metrics and the results are very promising:

1) Formation Charging: (No change in formation time, but charging voltage is reduced by 200mV)
2) RC and C-20 Capacity: (3% increase in RC)
3) Cold Cranking Amps Performance: (15% increase in cold cranking duration)
4) OCV Decay – Testing in process
5) Charge Acceptance: (65% increase)
6) Charge Current Increase: (280% increase), which reduces stratification and sulphation
7) Life Cycle Study – Testing in process
8) Tafels Study – (Reduce polarization voltage by 100 mV)
9) Pulse Power Rate at Various SOC – (Increase observed, testing underway)

Research indicates usage of Molecular Rebar™ will increase charge acceptance and reduce stratification and sulphation related failure, increasing life by at least by 30%, in **all application areas**.

Moreover, **there is no need for special machines or major modification to processing** for pasting; the paste density remains the same. Hence, it is manufacturer friendly.

As of today, **the hypothesis is that Molecular Rebar™ alters the crystal size of lead and interferes with hydrogen evolution in addition to reducing resistance by increasing surface area and interconnectivity via nano-wiring**.

A full, detailed, white-paper is scheduled to be published in December 2013. For inquiries on this abstract or to request to be on the distribution list of the white paper please contact Steven Swogger at swswogger@molecularrebar.com.