Dr. E. Jennings Taylor • Faraday Technology, Inc.
315 Huls Drive • Clayton, OH 45315-8983 • E-mail: Jennings@erinet.com

Chemically Mediated Metal Finishing Processes & the Founders of Electrochemistry

At the 5th International Pulse Plating Symposium, held in conjunction with SUR/FIN® 2000, 20 papers were presented during four sessions over two days. The symposium was an excellent forum for gaining knowledge and insight regarding non-DC electrochemical processes. These non-DC processes included cathodic processes, such as plating, as well as anodic processes, such as anodizing, machining, polishing, and deburring. In fact, this breadth of non-DC applications has prompted AESF to make a committee name change from "Pulse Electrodeposition Processes Committee" to "Pulse ***Electrochemical*** Processes Committee."

An important emerging trend that I gleaned from the symposium was the knowledge-based approach to non-DC process development and the possibility of electrical mediation in place of chemical mediation. While I pondered these possibilities, I found my mind drifting. I attempted to rationalize the foundations of the long-standing art of chemical mediation and the perpetuation of the plating wizard and his vat of magic additives presented in this column last month.

An excellent starting point regarding the "history and folklore" of chemical mediation is the chapter on additives in Jack Dini's book on electrodeposition.[1] As evident in the literature, considerable serendipity was involved in the discovery of additives used to chemically mediate metal finishing processes.

Even after exploring the fascinating literature regarding the discovery of various additives, I found myself pondering the origins of the science of electrochemistry. As a fortunate aid to my musings (or unfortunate, depending on how you read the rest of this article), an engineering colleague loaned me an out-of-print book called *The Founders of Electrochemistry*.[2] This book discusses the lives and activities of:

- Count Rumford—as founder of the Royal Institution of Great Britain, where much of the groundbreaking work in the field of electrochemistry took place,
- Alessandro Volta—as motivator of the electrochemical revolution (more about that later),
- Humphry Davy—as innovator in electrochemistry and mentor to
- Michael Faraday—who is generally acknowledged to be the father of electrochemistry.

Certainly all metal finishers recognize the importance of Faraday's discovery of the relationship "between the 'ordinary chemical equivalent' and the 'electrochemical equivalent.' " In addition to Faraday's Constant or the Faraday of charge, Michael Faraday is credited with establishing the use of terms we, as electrochemists, take for granted: *electrode*, *electrolyte*, *electrolysis*, *anode*, *cathode*, *anion*, *cation*, and *ion*. But, what about the "motivator" that facilitated Michael Faraday's discoveries and started the electrochemical revolution?

A Breakthrough for Electrochemistry

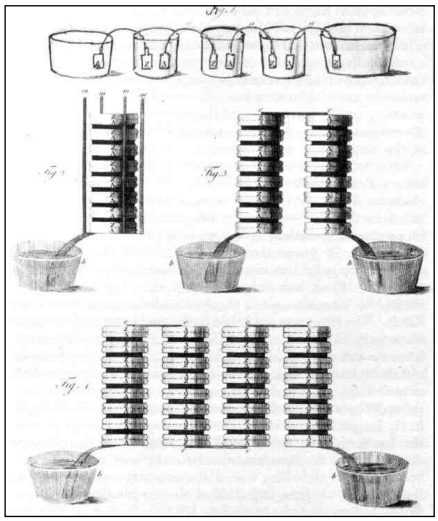
Prior to Faraday's groundbreaking work, the phenomena of electricity was studied using electrostatic generators. A common type of generator used rotating and stationary insulting surfaces to generate "static" electricity. The static charge could be built up in a condenser or capacitor, such as the Leyden jar.

While the electrostatic generator in combination with the Leyden jar could store a considerable amount of charge or energy, it was limited to intermittent discharges in the microsecond range.[3]

However, in a letter to the president of the Royal Society, Alessandro Volta described a means for producing a continuous flow of electricity, *i.e.*, DC electricity, based on[4]

"…an action inherent in the dissimilar metals in contact with the moistened spacer."

The Volta Pile—essentially a battery—truly provided the tool for the subsequent critical discoveries by Michael Faraday and others, which led to establishing the science of electrochemistry. The Volta Pile was the precursor to the modern day DC rectifier. The limitations of DC process control necessitated the creation of chemical mediation.



The Volta Pile as depicted in Volta's letter to Sir Joseph Banks. At the top is shown the "crown of cups" and below it variant arrangements of A (silver, for argentium) and Z, zinc discs with moist paper separators. Courtesy of Burndy Library.[2]

What If?

To continue my fanciful musings, what if Volta had invented a means for producing continuous discharges of electricity? Further, suppose that the duration, polarity, and asymmetry of these discharges could be controlled. Yes, the modern day invention I am referring to is the periodic pulse-reverse rectifier!

As my musings neared their end, I surmised that Michael Faraday, with the appropriate tool, would have not only established the electrochemical equivalent, but would have also discovered electrical mediation of electrochemical processes. Support for my hypothesis that Faraday was limited by the tools available to him rather than his ability comes from a lecture[5] delivered by John Tyndall at the Royal Institution in 1868:p

"…Michael Faraday was the greatest experimental philosopher the world has ever seen…and the progress of future research will tend not to dim or diminish…the labors of this mighty investigator."

But, alas, not only are we lacking in Faraday's intellect, we are also burdened with two centuries of familiarity with chemical mediation. As John Tyndall[6] further noted:

"(While our paradigms) … afford peaceful lodging to the intellect for a time … they also circumscribe it, and by and by, when the mind has grown too large for its lodging, it often finds difficulty in breaking down the walls of what has become its prison instead of its home."

Breaking Out!

So, how are metal finishers to break down the walls of the prison of the chemical mediation paradigm? The hammer or pick axe that will assist metal finishers in breaking down the prison walls is the need for more demanding engineered surfaces.

I reiterate from last month's column that metal finishers must demand "show-how" as well as know-how. Such demand will eliminate the consultants from the industry who simply jump on the bandwagon of the latest fad, make a quick buck, and destroy the credibility and potential of new and novel processes. I can think of no better example then the hiatus from pulse plating after the early successes associated with lead-frame plating. The same basic forward-only waveform was inappropriately applied to numerous problems, leading metal finishers to conclude that pulse plating didn't work.

The process suppliers must work in concert with the metal finishers and deliver the know-how and the show-how associated with electrical mediation. When electrical mediation can circumvent chemical mediation, the process suppliers must not continue to perpetuate the false need for their magic additives. In turn, metal finishers must recognize the value of credible process suppliers and compensate them based on the value they create, not on the purchase of some magic elixir.

I conclude by noting that the current state of affairs regarding the prison of chemical mediation is not limited solely to plating. The magic brews and special electrolytes are also well entrenched in such anodic processes as machining, deburring, and polishing. P&SF

References

1. Jack W. Dini, *Electrodeposition: The Materials Science of Coatings and Substrates*, Noyes Publications, Park Ridge, NJ (1993).
2. Samuel Ruben, *The Founders of Electrochemistry*, Dorrance & Co., Philadelphia, PA (1975).
3. *Ibid.* p. 27.
4. *Ibid.* p. 35.
5. John Tyndall, *Faraday as a Discoverer*, pt. VII, Thomas Y. Crowell Company, New York, NY (1961).
6. *Ibid* p. 64.