Magnetic Water Treatment:

After 50 Years, Still More Questions Than Answers

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Several years ago, I received an email from a man who owned a small sawmill in Oregon. The boiler that powered his lumber-drying kiln had to be shut down so frequently to remove scale that the economic viability of the business was at risk. Finally, in desperation, he installed a magnetic device on his boiler feedwater line, after which his scaling problems disappeared. Shortly after this, he had seen my Web page that expressed doubts about the efficacy of magnetic water treatment (MWT) and he felt the need to relate his experiences to me.

Of course, every chemist knows that water molecules are not affected by magnetic fields and that the idea that an externally applied field can cause the oppositely charged hardness ions to drift toward each other and coalesce into crystallization nuclei instead of depositing out as surface scale is hopelessly simplistic. But scientific knowledge is built on models of the world that are never really complete. For many years, I enjoyed proving to my students that gas vapor bubbles can never form in a liquid or that liquid drops cannot condense out of a gas—implying that water can never boil and that rain can never fall! These conclusions have largely been verified for the ideal models of perfectly uniform liquids and gases that are free of particles of dust or other solids; only when we extend our models include these imperfections do observations agree with theory.

There is a long history of the promotion of magnets to alleviate the hardness of mineral-containing waters, and particularly to control the deposition of scale in teapots, plumbing systems, evaporators and boilers. There is now a large variety of devices on the market that claim to reduce scale deposition and some claim to soften the water as well.

Although MWT products have been promoted since the 1930s, they have not received very wide acceptance within the engineering community and the question of whether or not they are effective is still very much open. The widespread marketing of MWT products to consumers via the Internet has done little to settle the issue.

Most descriptions of MWT don't claim to remove the hardness ions from the water (as conventional ion-exchange softeners do). Most commonly, the lime scale solids are claimed either to deposit in a loosely adherent flake-like form or precipitate as small particles within the water itself instead of on metal surfaces. In either case, the precipitated material is carried along with the water. One would expect that this could be confirmed by collecting the precipitated particles in a micropore filter or observing them indirectly by light-scattering measurements, but only one study of this kind (and not a particularly complete or convincing one) has been reported in the scientific literature.

Wider interest in MWT began in 1985, when Klaus Kronenberg, a physics professor at the California State Polytechnic University, presented a paper at a conference in which he reported that passage of hard water through a magnetic field (or even better, through a succession of closely-spaced fields) will alter the shapes of the carbonate solids that remain after the water has evaporated. His photographs show that the crystals are more loose and flake-like than when formed from untreated water. This finding, which has not been followed up on in a comprehensive way, has been widely cited to support the claims of the many vendors of MWT devices that began to be widely marketed as the Internet developed over the next several years.

The first MWT devices employed permanent magnets and many still do. In recent years, electrically-operated devices have become widely available. These mostly pass an alternating current, usually somewhere in the 100-1,000 Hz frequency region, through a solenoid coil that surrounds the pipe.

Does MWT work?

There are really two aspects of MWT. One of these is water softening which would imply complete removal of dissolved salts from water, preventing formation of soap scum and deposits of solids when water evaporates. To accomplish this feat by magnetic means alone would violate several fundamental laws of physics—and there is no evidence that it has ever been accomplished—although few of the sales promotions go out of their way to call attention to this fact.

The matter of magnetic scale control (MSC), which is of interest not only to residential consumers but becomes crucial to operators of industrial boilers and evaporators, is somewhat more cloudy. One might think that the question would have long been settled by scientific and engineering studies, but this has never happened.

- Most of the reports (and there have been many) of the successful use of MSC have been anecdotal and lacking in quantitative data and proper controls.
- Most chemists and chemical engineers who have looked into MWT remain very skeptical, as scientists tend of be of any field for which there is no obvious theoretical model and in which quantitative and reproducible results are hard to come by. (A very similar situation arises in studies of whether power transmission lines contribute to leukemia.) Scientists who might otherwise be qualified to investigate MSC, also tend to be put off by the stigma the field has acquired due to the exaggerated claims made by some of its adherents and the widespread promotion of various worthless applications involving magnets.
- Most water-treatment engineers who have investigated MSC in controlled industrial settings report negative results. Most commercial promotions of MWT devices tend to make excessively optimistic claims without offering credible supporting performance data. And the case studies that are occasionally offered are rarely researched to engineering standards and frequently difficult if not impossible to verify.
- There are very few scientifically validated reports of successful MSC installations in the mainstream scientific and engineering literature. Given the potential economic benefits of a widely applicable, chemical-free softening process (especially in arid regions such as the US southwest), one would expect a lot more scientific and engineering support.
- Many of the reports supporting MSC seem to appear in rather obscure journals and conference proceedings. This may in part reflect the fact that

water treatment not generally thought of as cutting-edge science, despite its importance and the fact that much remains unknown about the mechanisms of precipitation and scale formation.
- Manufacturers of MSC devices commonly offer simplistic or scientifically untenable explanations of how these devices work. This reflects badly on both the competence and honesty of those who promote the product.
- Although MSC appears to be effective in some cases, the dependence upon operating parameters such as water composition, magnetic field strength, treatment geometry and flow rate that are required for satisfactory performance have never been clearly defined. Closer study often reveals that other factors (such as seasonal changes in water composition) could account for the improvements that might otherwise be attributed to MSC.

In a technical paper presented at the 2004 International Water Conference in Pittsburgh, Pa., Chemical Engineer Timothy Keister notes that, "In contrast to the testimonials common to NCD (non-chemical devices) marketing literature, the many controlled studies undertaken by various government and industrial organizations have resulted in a consensus opinion that NCD are not capable of producing the effects claimed in the literature. In general, the theories advanced by the NCD suppliers to explain operation of their devices show a lack of agreement with accepted scientific principles. In spite of an extensive history of installation failures, findings of no effect in controlled studies and no acceptable theory of operation; new NCD are accepted in the market on a routine basis, often obtaining significant sales before the inevitable disasters result in that particular device being discredited."

In several very detailed case histories (mostly concerning alternating-current MSC systems), Keister concludes that in every instance, the observed reduction in scaling could be attributed to changes in operating procedures or to other aspects of water chemistry.

Magnetic marketing hype

Although the question of whether or under what conditions MWT can be effective remains unsettled in the scientific and engineering communities, the vendors of these devices are not inhibited by such doubts. It's fair to assume that most MWT vendors truly believe in their products and many even offer money-back guarantees. Nevertheless, much of their promotional literature consists of intertwined threads of science, scientific-sounding nonsense and outright untruths that can only mislead the average consumer.

Some of this reflects the scientific ignorance of the promoters themselves. A good example is a water-softening device that was developed by a manufacturer of radio-transmitting antennas. Knowing that a dipole antenna works by having the electrons within it shoved back and forth between its two ends, these people developed a device that supplies a high-frequency signal to a coil that supposedly couples this energy into a water pipe that, as implied by a diagram on their Web page, induces a similar alternating flow of electrons within the water contained in the plumbing system. The idea, apparently, is that these electrons sweep the positive and negative hardness ions along toward each other, causing them to collide and coalesce into tiny particles before they can form scale on the inside surface of the pipe. But as any chemist (but perhaps not every radio engineer) knows, freely mobile electrons cannot exist within liquids as they can in metals and ions are too large to move rapidly through the hydrogen-bonded network of water molecules.

Ignorance, of course, can easily be extended to wishful flights of fancy. Consider the following quotes from some prominent manufacturers of WMT devices:

- When water is magnetically charged, it electrically takes on a greater ionic charge than the minerals which creates a natural magnetic attraction between the two... Softening and better taste occurs from an actual reduction in the size of the water molecule... The small magnetized water molecule has a greater solvency and a magnetic attraction that results in cleaner bathing and washing which cleans and washes like soft water. The smaller molecular size also has less evaporitive [*sic*] surface area which magnetically and dramatically reduces the gases and foul taste of sulfur, chlorine and fluoride, etc.
- As water moves through the induced magnetic field, the static charge on the water molecules is changed from negative to positive due to current being generated by the moving water (Faraday's Law). The current produced by the flow also causes some water molecules to ionize (dissociate), forming hydronium ions (H^+) and hydroxyl ions (OH^-). Oxidation (corrosion) is prevented by the physical fact that the negative oxygen is repelled by the ground negative (cathodically protected) pipe. Negative scale ions are also repelled. (Basic law of Physics: similarities repel) If walls of negative pipe are contaminated with hard deposits (scale), positive hydronium ions work to convert hard deposits (scale) into soft deposits (aragonite), which are eventually removed and precipitate out into the tower basin.
- It has been firmly established in the world scientific theatre that the positive, expanding, field influence of the South Pole makes liquids more soluble (lowering surface tension); thereby hydrating, dissolving, and removing calcite and other mineral/various water by-product build-up in pipes and equipment. The positive field hydrates all mineral build-up by de-clustering the liquid and solid pre- and post nucleated crystalline scale material.

Every statement in the above quotations is untrue or simply nonsense! Although these pieces of fiction are guaranteed to elicit howls of laughter from anyone who has recently passed an introductory chemistry course, they can sound quite convincing to the majority of consumers.

From fuel enhancers to laundry balls

If magnets can work wonders with water, why not with other fluids as well? There is a highly hyped market for magnetic fuel enhancers that make the ridiculous claims that they:

- break up [nonexistent] "clusters" of hydrocarbon molecules, thereby exposing the previously-shielded atoms to combustion;
- convert the hydrocarbons to "positive ions" which are more strongly attracted to the 'negatively charged air molecules' (purportedly created by another magnet on the air intake);
- change the hydrocarbon molecule from its *para* [spin] state to the higher-energized *ortho* state.

There seems to be no end to it! One prominent magnet merchant advertises 'magnets for water, engines, pool, spas, plants.' For your car, you can buy a set of three magnets designed to be installed on the fuel line, on the radiator hose and on the air intake.

The very flimsy justification for the claims mentioned above, probably comes from the belief that magnetic fields can reduce the surface tension of water, implying that the weak bonds that hold the water molecules together are broken up. This idea, for which there is no credible evidence, has become almost an urban legend that is widely promoted by a variety of hucksters. It has launched an entire industry of magnetic disks or balls that one throws into a washing machine along with the dirty clothes. The idea is that by breaking up the water 'clusters', the individual molecules are able to penetrate into the fabric more efficiently, allowing the consumer to reduce the amount of laundry detergent needed. One wonders if a rock would not do just as well!

About the author

♦ *Stephen Lower is a retired chemistry professor at Simon Fraser University in Vancouver, Canada. His AquaScams Web site (http://www.chem1.com/CQ/) debunks water-related pseudoscience and quackery.*