Research and Development on Magneto-Rheological Fluids

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Introduction:

The collection and preservation of tool mark and impression evidence is an important part in the field of criminalistics. The ability to discern class and individual characteristics and use these to either identify or exclude an item as a possible match is a powerful tool in a criminalist's arsenal. The ability of a casting agent to resolve the fine details of an impression is of the utmost importance. An innovative approach to this problem is utilizing Magneto-Rheological fluids as an agent to capture impression in situ. These materials are fluid under most conditions, but form a solid when a magnetic field is applied to them and can be used instead of dental stone or Mikrosil for collecting impression evidence. By varying the size of the magnetic particles suspended within the fluid as well as the other components used the resolving capabilities of the MR fluids as a casting agent can be fine-tuned to suit the job at hand. Optimizing an aqueous and oil based MR fluid will be the focus of this study.

Water	1.5mL	2.0mL	2.5mL	3.0mL	3.5mL	4.0mL	4.5mL
Iron powder	10g	10g	10g	10g	10g	10g	10g
Sodium Nitrate	0.3g	0.3g	0.3g	0.3g	0.3g	0.3g	0.3g
Sodium Chloride	0.07g	0.07g	0.07g	0.07g	0.07g	0.07g	0.07g
Cellulose	0.3g	0.3g	0.3g	0.3g	0.3g	0.3g	0.3g

Table 1: Formulas for aqueous MR fluid with varying water content.

Water	3.5mL	3.5mL	3.5mL	3.5mL	3.5mL	3.5mL	3.5mL
Iron powder	2.5g	5g	10g	15g	20g	25g	30g
Sodium Nitrate	0.3g	0.3g	0.3g	0.3g	0.3g	0.3g	0.3g
Sodium Chloride	0.07g	0.07g	0.07g	0.07g	0.07g	0.07g	0.07g
Cellulose	0.3g	0.3g	0.3g	0.3g	0.3g	0.3g	0.3g

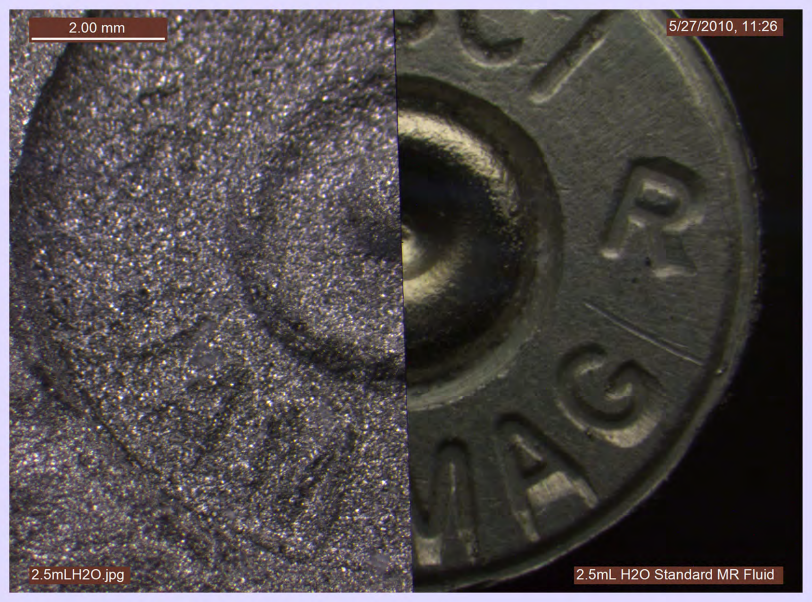
Table 2: Formulas for aqueous MR fluid with varying iron powder content.

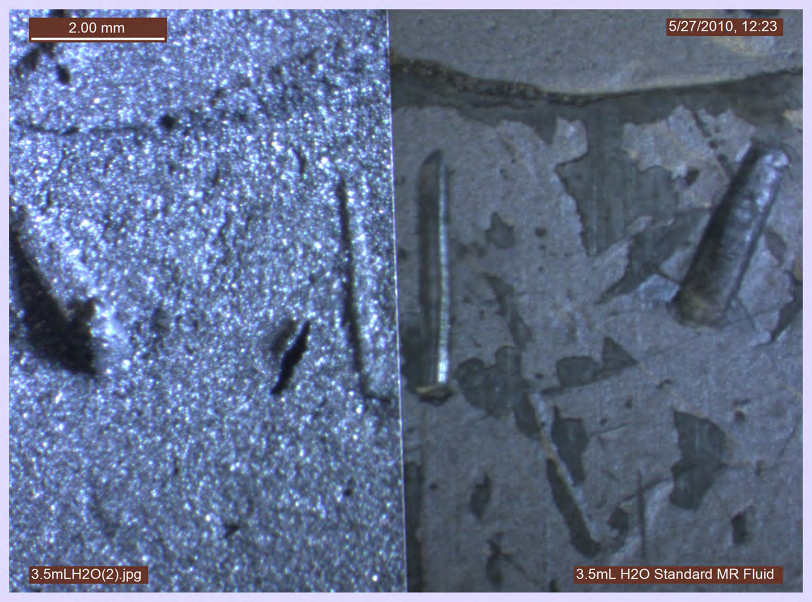
Materials and Methods:

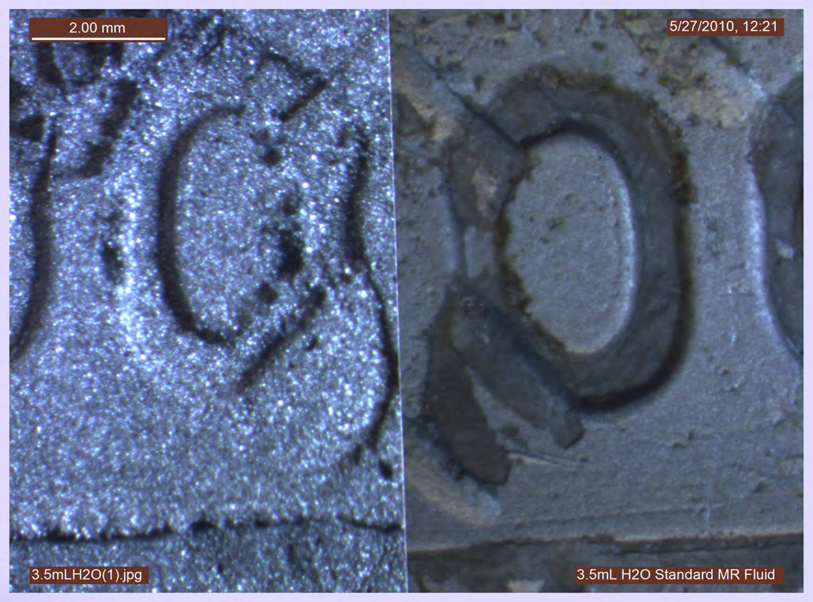
The composition of the MR Fluid will follow a general formula as follows. The magnetic particles to be suspended in fluid will be iron powder of a standard mesh size of 200, with the larger the number in the mesh size corresponding to a smaller particle size. .Larger particle sizes yield a more solid and durable cast while providing less detail when in the magnetic field, whereas smaller particles will give more resolution to the cast but at a slight cost of rigidity. A suspending agent will hold the particles from settling. This increases the shelf life of the MR fluid and prevents the iron particles from settling. This powder mix is then added to a measured amount of fluid.

In the case of aqueous MR fluid the components of the mixture are not the same. The suspending agent used is cellulose. The fluid used is water. 200-mesh iron powder is still being used because it was the best size in terms of durability and resolution of the cast made. Also being used in the aqueous based fluid is sodium chloride and sodium nitrate. Sodium nitrate prevents oxidation of the iron powder while in solution and sodium chloride helps in dissolving of the cellulose.

For the first experiment done the MR fluid was composed of: 100g of 200mesh iron powder, 3g of cellulose, 3g of sodium nitrate, 0.75g of sodium chloride, and 25mL of water. From this formula an experiment was devised in which the water content was varied from 15mL to 45mL while keeping the rest of the components of the fluid the same. Also 1/10th of all materials were used in order to save on resources.







Conclusion:

The goal of this research was to optimize a working MR fluid for use on impression evidence. Over the course of the experiment it was seen that use of MR fluid is very promising in this field. These results show that it has equivalent resolving capabilities to Mikrosil casting putty and far better than dental stone. Also, it is able to do this with minimal disturbance to the surface being cast. Both the Mikrosil and the dental stone caused damage to the substrate.

Another advantage of magneto rheological fluids is the ease of preparation and use. Mikrosil must be mixed and used within 30 seconds before it starts to set. Dental stone has the opposite problem, requiring hours to set, and a day to cure fully. MR fluid remains a fluid for as long as necessary, requiring at most agitation to resuspend any iron particles that may have fallen out of solution. The MR fluid then becomes solid instantly upon application of the magnetic field, and remains solid for as long as the magnetic field remains.

No technique is without its disadvantages, and MR fluids are no exception. As with any new technique, it will require time to train and familiarize crime scene processors with the new technology. Fortunately, because techniques involving MR fluids involve no elaborate chemical reactions, training individuals in their use should be as quick as a hand on demonstration, requiring no additional formal education. Additionally, because this is the first time MR fluids are being used in this capacity, specialized equipment has yet to be designed for use in the field. Electromagnets and voltage transformers are bulky and heavy, as well as a costly start-up expense. Once these materials and techniques become more widely spread, however, the demand for specialized tools will bring both the size and the costs of this type of equipment down.

There still remains work to be done to enhance the use of MR fluids as a tool in the crime scene processor's arsenal, but it has the potential to be a powerful asset for anyone investigating the origins of impression evidence.

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