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Coating Magnesium, Part I

Introduction:
Powdered magnesium is one of the most reactive metals used in pyrotechnics. Magnesium is vulnerable to attack by many salts, sulfur compounds, acids and even water. Even boric acid, which is commonly used to protect aluminum in the presence of nitrates, will react with magnesium. Unfortunately, some of the more active reactions occur with oxidizers and color agents commonly used in pyrotechnic formulas, such as copper sulfate, ammonium perchlorate, sodium bicarbonate, potassium chlorate, potassium perchlorate, potassium nitrate and strontium nitrate to name just a few. The perchlorate and nitrate reactions are not quite as strong at room temperature, and keeping the materials very dry helps slow down reactions as well. However, even these less reactive ingredients have the potential to cause problems if the material is to be stored for very long.

Magnesium is also among the most expensive metals used in pyrotechnics, especially for the hobbyist trying to obtain the material in small quantities. Recent shipping restrictions in the U.S. have made magnesium particularly difficult to obtain. The few hobby suppliers that do carry the desired atomized magnesium are forced to dilute it with 50% of useless magnesium turnings in order to ship it. Thus the cost of an already expensive metal is effectively doubled by yet another arbitrary and futile regulation in the name of "safety."

So with the high cost and problematic reactivity of magnesium, why does anyone use it at all? Well, like every other hazardous or expensive chemical that tempts us with the promise of better quality effects, magnesium offers a purity and brightness of color that is unmatched by any other metal fuel. Adding even a small amount of magnesium to an existing color formula can often create added brilliance without washing out the color quality any noticeable amount. Where colored strobes are concerned, magnesium in combination with ammonium perchlorate produce the best and brightest colors possible. For colored flash formulas such as those used in Maltese Beraq formulas, magnesium is a critical component that can not be substituted by any other metal without total color loss.

Assuming you can get past the financial barrier to using magnesium, the next step is to overcome the reactivity problems by coating it with a suitable protective barrier. There are several materials available for doing this, each with different levels of protection. The three most common coatings are shown in the table below, which indicates the level of protection provided by linseed oil, paraffin and potassium dichromate for a group of the most problematic chemicals.

Protection of Magnesium Coatings
(tested in wet state at room temperature)

	Uncoated	Linseed Oil	Parafin	Potassium Dichromate
Water	x	o	o	o
Ammonium Perchlorate	xxxx	xxxx	xxxx	s
Potassium Chlorate	xxx	o	xx	s
Potassium Perchlorate	xxxx	o	xx	s
Barium Nitrate	xxx	o	s	s
Strontium Nitrate	xxx	o	s	s
Potassium Nitrate	xxx	o	s	s
Sodium Nitrate	xxx	o	o	s

o: No reaction occurs.
s: Slight reaction, but useful in practice.
x: Attacked slowly.
xx: Attacked considerably.
xxx: Attacked actively.
xxxx: Attacked violently.

Source: *Fireworks, Art, Science and Technique* by Takeo Shimizu, Ph.D.

It is seen that Linseed Oil would be the perfect all-purpose coating were it not for the one pesky case of ammonium perchlorate. Potassium dichromate is the only coating that will protect against contact with ammonium perchlorate. Since the color and strobe formulas containing magnesium in combination with ammonium perchlorate produce the best color purity available, you will eventually find yourself wanting to use them when producing the best possible effects. For all other cases it is better to coat your magnesium with linseed oil, if for no other reason than to avoid the toxic hazard of working with potassium dichromate.

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Figure 1: Close-up of potassium dichromate crystals.

Figure 2: 1000g of magnesium with 10 oz of dichromate solution.

Figure 3: The coated magnesium after

Coating with Dichromate

As seems to be a general rule in pyrotechnics, the chemical that does the best job is also the most hazardous to your health. Potassium dichromate (also called bichromate) is one of the more hazardous substances on your chemical shelf, but it is the only option for preparing magnesium that will be coming into contact with ammonium perchlorate. A close-up of the bright orange potassium dichromate crystals can be seen in Figure 1, which is poisonous, corrosive and carcinogenic stuff that you don't want coming in contact with any part of your body. Read the full MSDS warnings here.

Prepare the magnesium to be coated by running it through a 50 mesh screen to remove any large chunks and break up any lumps that can sometimes form while sitting in storage. The magnesium is then transferred into a metal cooking pan similar to the one shown in Figure 2, then placed in an oven set to 210 degrees F (100 degrees C) for one hour.

The amount of dichromate used to coat the magnesium is weighed out as 5% of the weight of the magnesium to be coated. For this example we are coating 1000 grams, so 50 grams of dichromate would be weighed out and dissolved into 10 ounces of hot water (300 cc). The volume of water is adjusted to maintain the same ratio for producing larger or smaller batches of magnesium (example: 20 ounces for a 2000g batch).

After removing the heated magnesium from the oven, quickly add the warm dichromate solution and mix it in using gloved hands. This should be done out doors while wearing a respirator. It is important to avoid skin contact with the dichromate solution, as it will burn your skin and can even cause cancer with repeated exposure over time.

Once the solution has been completely worked into the powder so that there are no more dry spots, the damp magnesium is spread out on a sheet of paper to dry. A drying box can be used to accelerate this process, but care must be taken not to let the powder fully dry before screening it the first time.

While the powder is still slightly damp, run it through a 30 mesh screen in order to break up the clumps. If the powder is allowed to fully dry, the clumps will be more difficult to return to a powdered state. This is one of the tricks to making this process easier. After screening one time, allow the powder to fully dry and then screen one final time. It is especially important to wear the respirator and screening.

work outside during this screening process, as the poisonous dichromate dust will become airborne.

Once dry, you should have a greenish yellow pile of free-flowing magnesium as seen in Figure 3. The procedure is really quite simple once you can get past your phobia of the scary orange stuff!

Despite the extra safety precautions that must be taken when dealing with hexavalent chromium, some commercial manufacturers still find it faster and more economical to treat their magnesium with dichromium rather than deal with the more time consuming methods of coating with linseed oil. The hazardous leftovers and waste water from dichromium operations can be treated with ferric sulfate in order to convert the hexavalent chromium to a less toxic trivalent state prior to disposal.

For the hobbyist, the extra labor and extended drying time when coating magnesium with linseed oil may be worth the effort if it means not having to worry about avoiding contact with dichromium. In part II of this article we will look at the procedure for preparing linseed oil and coating magnesium with it.