Homemade Gaslight Mantles **Ludwig Gebauer 24.8.2004**

First a word of caution. The process of making incandescent mantles involves handling chemicals and although I made some effort to create a recipe based on the use of comparatively harmless chemicals some precautions are necessary.
Keep everything out of the reach of children, do not store the chemicals or finished articles near food. Do not handle the raw materials or finished mantles in the kitchen. Avoid contact with eyes and skin so wear rubber gloves and a protective eye mask. Ensure absolute cleanliness. This is not really for safety reasons but because traces of impurities such as Iron, copper, or talcum from disposable latex gloves, may affect the quality of the results.

Secondly a note: This is not intended to be the definitive method to create mantles. It is rather in the nature of an experiment to discover the secrets commercial mantle manufacturers might have. The answer to that is they have none or at least none that could not be found by normal experimental development which of course would involve an extensive series of tests. The following describes how I succeeded and suggests some possible hints for possible improvements.

In principle making mantles is simple. An absorptive textile fabric of a suitable shape is impregnated with a solution of suitable metal salts and dried.

Impregnation Solution

Until a few years ago, mantles in burned-in condition consisted of 99.1 % thorium oxide and 0.9 % cerium oxide. Since thorium fell into disrepute because of its (very weak) radioactivity a few years ago, today (Modern) mantle manufacturers use yttrium oxide instead.

Cerium and yttrium must be converted to a water soluble form. For this purpose, mantle manufacturers use nitric acid salts (nitrates) of the mentioned metals. Since the handling of nitric acid is not especially pleasant, and because it is not always easily available for the hobby chemist, I use acetic acid instead1,2).

Chemicals Required:

Yttrium oxide 99.9 %
Cerium(IV) sulphate tetra hydrate
Distilled water
Acetic acid 25 %

As a source of supply for yttrium oxide and cerium oxide, normal suppliers of laboratory chemicals, e.g. Merck or Sigma-Aldrich, may be considered, through a local distributor of industrial chemicals. Distilled water should be no problem, and acetic acid of the required purity is available, at least in Germany, in every super market as „Essigessenz“ („Vinegar essence“).

Tools required:

Precision balance, accuracy at least +/- 0.1 g, or if possible +/- 0.01 g
Suitable reaction container, or retort. e.g. a 750 ml preserving jar with glass cap, rubber gasket and knee lever lock or a glass bottle with plastic cap (Not a metal cap!)
A water bath that can be heated on a hot plate or burner, in which the retort may be immersed, so that the liquid level inside the vessel is below the outside water level.

Highly recommended:
A magnetic stirrer with magnetic stirring bar capable of being used in the retort whilst it is being heated.

Weigh into the retort:

10 g Yttrium oxide
0.4 g Cerium(IV) sulphate tetra hydrate
75 g Acetic acid 25 %
225 g Distilled water

The retort is closed and heated in the boiling water bath. During heating, the retort should be agitated to avoid settling of the yttrium oxide. Due to thermal expansion during heating, some pressure will build up in the vessel. If a bottle is used, the cap should be opened occasionally to prevent it from bursting. If the mentioned preserving jar is used, the pressure will automatically open the cap sufficiently to release excessive pressure; nevertheless some care should be taken when agitating to prevent liquid from leaking out. The temperature must be maintained for 3 – 4 hours. During this time the yttrium oxide will dissolve. The milky turbid liquid gets nearly clear, only a very slight, transparent residue may remain.

When the solution for impregnation has cooled to room temperature, it is ready for use. It can be prepared in advance; according to existing experience it is stable for at least 9 months.

This impregnation solution is not at all optimal. Due to the limited water solubility of yttrium acetate, it contains relatively little active substances; with nitric acid, more concentrated solutions should be obtainable. The remaining residue (Yttrium sulphate) could be avoided by the use of cerium(IV)ammonium nitrate instead of cerium(IV) sulphate, which is however more difficult to obtain. Experiments in these directions should only be carried out by people who are used to handling such chemicals. Possibly the ratio of cerium vs. yttrium may be not optimal, a little more or less cerium may yield better luminosity. I didn't try that because I considered the results I achieved with the above recipe to be sufficient.

Mantle Fabric

The material mantle manufactures normally use today is viscose („Rayon“). This is not readily available as crochet or knitting yarn, therefore Theodora and I use cotton. That is really only second choice, because it absorbs less solution than viscose. As, furthermore, the described solution is rather diluted, relatively thick cotton yarn is necessary to absorb the necessary amount of metal salts to produce sufficiently stable mantles.

For mantles of the size 150 - 250 cp a cotton yarn with a length near 250 m/50 g is required. For a mantle to fit a Petromax 250 cp ceramic nozzle, about 60 stitches should be taken up on 3.5 mm diameter knitting needles. Because mantles produced in this way are relatively thick,
it is not possible to simply knit a hose and to tie or sew the bottom afterwards as with commercially available mantles; like real stockings (Mantle in German: „Glühstrumpf“, „glowing stocking“) they must be knitted in a shape to resemble the final shape. When used, they shrink more than commercially produced mantles, therefore they must be knitted a bit larger than those.

After knitting the mantles must be thoroughly washed with washing detergent and thoroughly rinsed with water to remove any agents remaining from the spinning process, which will reduce the absorption capacity of the cotton yarn.

Impregnation...

...is simple. The mantles are immersed for some minutes into the impregnation solution until they are completely soaked. Then they are allowed to drip for some minutes (Do not squeeze or wring out!). For drying they are put over a suitable clean device (Preferably made of glass or plastic; no metal, no absorbent material like wood etc.), e.g. a liqueur glass or a bottleneck.

For fixing the mantles to the burner head, thin iron or stainless steel wire (Diameter 0.2 - 0.3 mm) may be used (Not copper wire because it will melt!). Fastening is critical because of the bulk of the mantles; Care should be taken to ensure a sound fastening so they do not slip down from the bulge of the mantle carrier because the new mantle will be thicker and with a thicker weave than a commercially produced one.

Literature:

1) C. K. Joergensen, Narrow Band Thermoluminescence (Candoluminescence) of Rare Earths in Auer Mantles, Structure and Bonding 25, Springer-Verlag Heidelberg, 1976, page 6.
2) Edita Garskaite, Darius Jasaitis, Aivaras Kareiva, Sol-Gel Preparation and Electrical Behaviour of Ln:YAG (Ln = Ce, Nd, Ho. ER), J.Serb.Chem.Soc 68(2003), page 677 ff.

Corrected for English syntax and spelling. Neil A McRae 25 August 2004