

## THE LOADING OF NUCLEAR EMULSIONS WITH BISMUTH

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There are various problems that can be studied by means of bismuth loaded emulsions, as for instance the natural alpha-radioactivity<sup>1</sup>, the fission and the fragmentation of this element. Being the heaviest element almost not radioactive, it is especially suited for the study of nuclear reactions on heavy elements induced by various primaries at various energies. For this reason, the problem of loading nuclear emulsions with bismuth has been often approached in the past, and several solutions have been found which, in general, offer some disadvantages. In 1948 Ilford started loading with tartrate or lactate salts, but it often happened that the loading resulted in the expulsion of the crystals from the emulsion. Furthermore, the hydrolysis of the bis-

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muth salt during the processing could sometimes result in regions of opacity and stains, so that special processing techniques were rendered necessary. In 1953 no more lactate or tartrate salts were to be found commercially, and Ilford discontinued this type of loading. In 1958 de Carvalho<sup>2</sup> present a solution to this problem by using a tetrasodic EDTA complex of bismuth. The main drawback of this method was that fading of the latent image was favoured, rendering impossible high radiation doses.

In our laboratory in Rome we have found a method of loading which solves all the problem mentioned. It is based on the use of bismuth citrate. It is well known that citrate salts have, as a rule, no harmful effects on nuclear emulsions. The difficulty in using bismuth citrate lies in the fact that this salt is not soluble in water. It is however soluble in alkaline or ammonia solutions. An ammonia solution is prepared in which a small amount of bismuth citrate is easily dissolved. In a second step, having already some bismuth citrate in solution, it is possible to dissolve a larger amount of the salt. The manipulation is as follows:

- 1) 1.7 g of 25% Merck ammonia are dissolved in 100 g of water;
- 2) very few bismuth citrate crystals are added and dissolved, heating slightly if necessary;
- 3) once this is done, up to 4 g of bismuth citrate may be added and dissolved;

- 4) to adjust the pH to about 6, nearly 1g of citric acid is added;
- 5) the solution is filtered, and a clear and transparent liquid is obtained with which to load the emulsions. It is very stable, also once loaded into the nuclear plates.

The loading techniques may be the standard ones. A possible method which we have successfully used is that of mixing and melting the bismuth solution with the nuclear emulsion in gel form as furnished by Ilford. In this manner we have loaded up to 120 mg of Bi per cubic centimetre of dry emulsion. The pellicles are of very fine quality, in fact quite better than those loaded with citrates of other elements. Both the surface - which is smooth and glossy - as well as the elastic properties are very satisfactory. Since bismuth desensitizes to some extent the nuclear emulsion, a proper choice of both gel type and developer is necessary. For example, to study the fission of bismuth we have obtained excellent fission tracks on an otherwise perfectly clear plate by using KO gel and the following developer:

10 g boric acid  
5 g sodium sulphite  
.5 g potassium bromide  
.45 g amidol

The processing was carried out with the following

## schedule:

- 2 hours washing in tap water at 8°C
- 4 hours development at 10°C
- 2 hours stop bath at 5°C
- 24 hours fixing at 4°C.

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