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ON THE PROCESSING OF NUCLEAR EMULSIONS

O. N. KAUL

SAHA INSTITUTE OF NUCLEAR PHYSICS

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ABSTRACT. The paper gives an account of the comparative study of the various processing formulae used by the author during the course of the emulsion work, using both thick and thin plates. Modified formulae for various processing stages found to give the best results have also been suggested.

The paper also gives the penetration time needed for various developers both in the case of presoaked and non-presoaked emulsions of various thicknesses, and also an account of the study of shrinkage factor in nuclear emulsions.

The author has made a detailed study of the processing technique using Ilford C_2 nuclear emulsions of 100, 200 and 400 micron thickness, and also K_0 and G_5 plates. The details of the investigation are given below under the various heads.

Pre-soaking stage

Before starting with the development, it is necessary to soak the emulsion in water, so that the penetration of the developer may become easier and more rapid. For this, the temperature and time limits suggested by various workers were used, and the following time and temperature limits were found to give the best results :

Emulsion thickness	Time	Temperature
100	0.5 hrs.	2°C
200	0.75 hrs.	4°C
400	1.25 hrs.	6°C

To facilitate penetration, presoaking in distilled water with or without the addtion of the wetting agent is frequently made use of. This acts to swell the gelatine, permitting more rapid diffusion of the developer. It, however, does not effect the actual development as with the alkaline developments (Dilworth *et al*, 1948; Mortier and Vermaesen, 1948; Picciotto, 1949). The suitable temperature at which the penetration is to occur has been found to be 4°C. Below this tem-

perature the penetration time was found to be too long, and above it, the rate of developer penetration increases less rapidly than its activity.

Development

Thin emulsions of 100 μm order :

Two degrees of development were found possible for thin emulsions. Moderate development was found useful when grain densities of comparatively dense tracks (e.g. protons and α tracks of several MeV energy) are to be measured. Since in this case it is essential that the grains be discrete, moderate development is preferred. This has an additional advantage of great reduction in the fog density. Strong development, on the other hand, although accompanied by an increased fog background, permits a full utilization of the emulsion sensitivity, and the heavy ionizing particles appear as solid columns of silver grains. Series of development tests were conducted to determine the development time giving the most preferred combination of background and track densities. The results thus obtained are indicated below :

Thickness	Procedure	Time
100	(moderate development)	10 min,
100	(strong development)	40 min.
		no agitation

Thick emulsions of 400 micron order and above

For thick emulsions, the two developer solution method as suggested by Blau and Defilice (1948) is found to give the best results to secure the even development. The first contains the developing agent without any alkali, permitting the diffusion of the developer into the emulsion without any appreciable amount of actual development occurring. The second bath containing an excess of alkali permits the development to take place.

This method requires that the velocity of the travel of a pH change should exceed that of the developer itself;—a condition which is not actually satisfied. Also, up to 400 μm thickness the two bath method eliminates any danger of reticulation.

It has been found by the author that the following modified formulae give the best results in the case of thick emulsions so far as two-bath development is concerned :

Sol. A.

Elon	1 gm
Sod. sulphite	20 gms
Hydroquinone	3.5 gms
Pot. bromide	2.0 gms
Distilled water	2 litres

Sol. B.

Stock Eastman D_{19}	...	400 c.c.
Distilled water	...	1600 c.c.
Sod. carbonate	...	12 gms

For 200 micron plates the following single solution development formula was found to give the best results. It is the Brussels formula slightly modified by the author :

Sod. sulphite	...	36 gms.
Pot bromide	...	0.8 gms.
Amidol	..	2.8 gms.
Boric acid	...	12 gms.
Water	...	1 lit.

Penetrating time needed for various developers

The penetration time in minutes of presoaked and non-presoaked emulsions was investigated by the author at 18°C.

Developer	*Penetration time in min.*		
Azol	100μm	200μm	400μm
Presoaked	4.5	16	38
Non-presoacked	6	19	50
D–19			
Presoaked	3.0	8.5	21
Non-presoaked	4.5	10.5	37
Amidol			
Presoaked	1.5	5.0	12
Non-presoaked	3.0	9.0	20
Amidol bisulphite			
Presoaked	2.5	6.0	12
Non-presoaked	2.5	8.0	20

Processing formulae of thick and thin emulsions : The following processing formulae were found to be most suitable for 100, 200 and 400 μm plates.

Stage	Temperature	Time in min.		
		100μm	200μm	400μm
Presoaking	4°C	30	40	100
	5°C	25	35	90
Penetration of the cold developer	4°C	30	40	100
	5°C	26	36	92
Warm dry development	18°C	25	40	80
	24°C	20	35	70
Dry cooling	18°C to 5°C	5	5	5
Stop bath acetic acid (0.5%)	5°C	30	45	100
,, (1.0%)	5°C	20	35	75
Fixation (clearing time +50% more)	18°C	3 hrs.	8 hrs.	24 hrs.
Washing	8°C	3 hrs.	8 hrs.	24 hrs.

The following processing formula was found exclusively suitable for thick plates :

Distilled water	1000 c.c.
Sod. sulphite (anhydrous)	12 gms.
Pot. bromide (10% solution)	8 cc
Amidol	3.8 gms.
pH of the developer	7.4

Fixing bath (pH 5.3)

Distilled water	1000 cc.
Sod. thiosulphate	400 gms
Sod. bisulphite	10 gms
NH_4Cl	7 gms

Clearing solution (pH 4.2)

Distilled water	500 cc
Ammonium acetate	15 gms
Citric acid	8 gms
Thio-urea	8 gms

Small quantities of sodium bisulphite and ammonium chloride reduce staining and hasten the fixation of the emulsion. But large concentrations of these ingredients lead to distortion. Further, in the fixing solution, one half of the quantity of hypo was replaced at several intervals, thus avoiding salt concentration shoak. For the same reason, washing was also preceded by a gradual dilution of the fixing solution.

Shrinkage

The considerable reduction in the thickness of nuclear emulsions after fixing is due to the high concentration of the silver bromide in nuclear emulsions. The ratio of the emulsion thickness before and after fixing were found, and the following results were observed :

Emulsion thickness in μm.	
Before processing	After processing
100	96
200	181
400	359

Increase in the shrinkage factor of Ilford C_2 emulsions :

The increase in the shrinkage factor of the emulsions was investigated at 80% relative humidity.

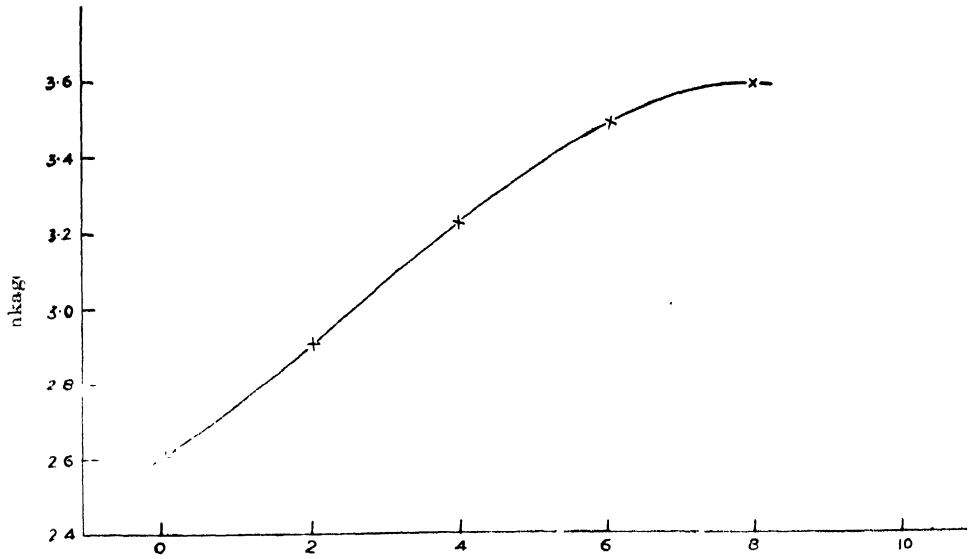

Fig. 1. Shrinkage factor plotted against the time of storage in hours for Ilford C_2 nuclear emulsions.

Drying of the emulsion

Plates of either thicknesses were soaked in glycerine solution and dried gently. Rapid drying was avoided, because it produces a skin at the surface which traps the water lower down. This in turn produces stresses at the soft emulsion which produce severe distortions in the tracks. Blowing over the surface was avoided, because it introduces severe distortions, although the temperature was slightly increased to accelerate the process (Dilworth, 1951). Edges of the plates usually dry first causing surface deformations in the emulsion, which was also minimized as far as possible.

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REFERENCES

Blau, M., and De Felice, J. A., 1948, *Phys. Rev.*, **74**, 1198.

Dilworth, C. C., Occhialini, G. P. S., and Vermaesen L., 1951, "Fundamental Mechanism of Photographic Sensitivity", Butterworth Scientific Publications London, p. 297.

Dilworth, C. C., Occhialini, G. P. S. and Payne, R. M., 1948, *Nature*, **164**, 102.

Mortier, M. and Vermaesen, L., 1948, *Centre de Physique Nucleaire de Bruxelles*, Note No. 5.

Picciotto, E., 1949a, *Compt. rend.* **228**, 173.

Picciotto, E., 1949b, *Compt. rend*, **228**, 2020.

Picciotto, E, 1949c, *Compt. rend.*, **229**, 117.