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THE TEMPERATURE DEPENDENCE OF THE RESPONSE OF 103a-0 AND Tri-X AT 4400Å

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ABSTRACT

Exposures of one-half hour duration at 4400Å were made on 103a-0 and Tri-X emulsions over a temperature range of +20°C to -77°C. The response of the 103a-0 was essentially unaffected by cooling. However, the sensitivity of the Tri-X was strongly temperature dependent, and it showed a maximum response near a bath temperature of -56°C.

INTRODUCTION

In a previous study (Hollars, 1970) a comparison of the response of Tri-X and 103a-0 at 4490Å showed that 103a-0 lost sensitivity as it was cooled while Tri-X showed a maximum response near -30°C. In this early study, the exposures were short (15 seconds) and the light levels were relatively high, thus, conditions were not typical for astronomy. In this follow-up study exposures have been more closely to those used in astronomical investigations. A combination of light level and exposure time was chosen that would allow the reciprocity adjustment of 103a-0 to be readily apparent.

EXPERIMENTAL PROCEDURE

A quartz-iodide lamp monitored to run at 3.5 amps and 8.9 VDC was used as a light source. Wavelength discrimination was provided by a 4400Å interference filter of approximately 100Å bandpass. A ten-step photographic wedge (calibrated at 4000Å) was imaged on 35mm film for each exposure. The film was exposed under vacuum conditions and cooled by contact with a cold platen. A complete description of the equipment has been given by Tifft and Nobles (1969).

On each type of emulsion, six exposures were made covering the temperature range from +20°C to -77°C in roughly equal increments. Coolant fluid was continually circulated from a cold bath to the film platen and back to the bath. The temperature of the coolant bath was determined with an alcohol thermometer. The slight amount of heating of the coolant fluid during transfer kept our lowest temperature from reaching that of dry ice (-78.5°C) which was used to cool the bath.

Exposures at $+20^{\circ}C$ and $+2^{\circ}C$ were done at atmospheric pressure since the dew point was low enough to prevent moisture from condensing on the film. Exposures at lower temperatures were done under a vacuum of approximately 60 . At each temperature an exposure was made on each emulsion. The pair was then developed together in D-19 for five minutes at $68^{\circ}F$. A final exposure of 103a-0 at $+20^{\circ}C$ was used to verify that there was no systematic change in the output of the lamp.

RESULTS

In Figure 1 we show the characteristic curves for the two emulsions. All the curves for 103a-0 fell within the bounds of the two dashed lines. The scatter in this region was not systematic with temperature. The same small scatter should exist in the Tri-X curves, but it is not apparent due to the strong temperature dependence. In these curves we have plotted density above background fog. The fog level was not strongly temperature dependent in either emulsion. The fog for the Tri-X was 0.30 density units at $+20^{\circ}C$ and slightly over 0.31 at $-77^{\circ}C$. The 103a-0 began at 0.20 and reached 0.21 at $-77^{\circ}C$. Since the scatter was very small, this may indicate a tendency for fog to increase as the temperature is lowered.

The temperature dependence of the sensitivity is shown more clearly in Figure 2. Here the relative exposure required to produce a density of 0.6 above background fog is plotted as a function of the bath temperature. The relative exposure is expressed as a per cent transmission normalized so that the exposure on Tri-X at $20^{\circ}C$ is 100%. Therefore, the Tri-X at $-56^{\circ}C$ required only 16.5% of the exposure at $20^{\circ}C$ to produce the same response. It is obvious, however, that the Tri-X at its optimum temperature never performs quite as well as 103a-0.

CONCLUSIONS

These results show that cooling can largely remove reciprocity failure in Tri-X emulsion at 4400Å for thirty-minute exposures. Additionally, the 103a-0, which is adjusted for reciprocity failure during manufacture, shows no temperature dependence for the same conditions. The optimum temperature for the Tri-X appears to shift to lower values for longer and fainter exposures.

In this study we were not directly concerned about the effect of the vacuum on the response of the film. However, in Figure 1 we notice a rather large increase in sensitivity in the toe of the curves for Tri-X at $-18^{\circ}C$ and cooler as compared to those at $+20^{\circ}C$ and $+2^{\circ}C$. This could, therefore, in part be caused by the evacuation.

ACKNOWLEDGEMENT

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REFERENCES

Hollars, D. R. 1970. NASA Technical Report T 70-17, "Temperature Effects on Photographic Sensitivity", Steward Observatory, University of Arizona, Tucson, Arizona.

Tifft, W. G. and Nobles, E. 1969. NASA Technical Report T 69-15, "A System for the Study of the Detection of Faint Astronomical Signals", Steward Observatory, University of Arizona, Tucson, Arizona.

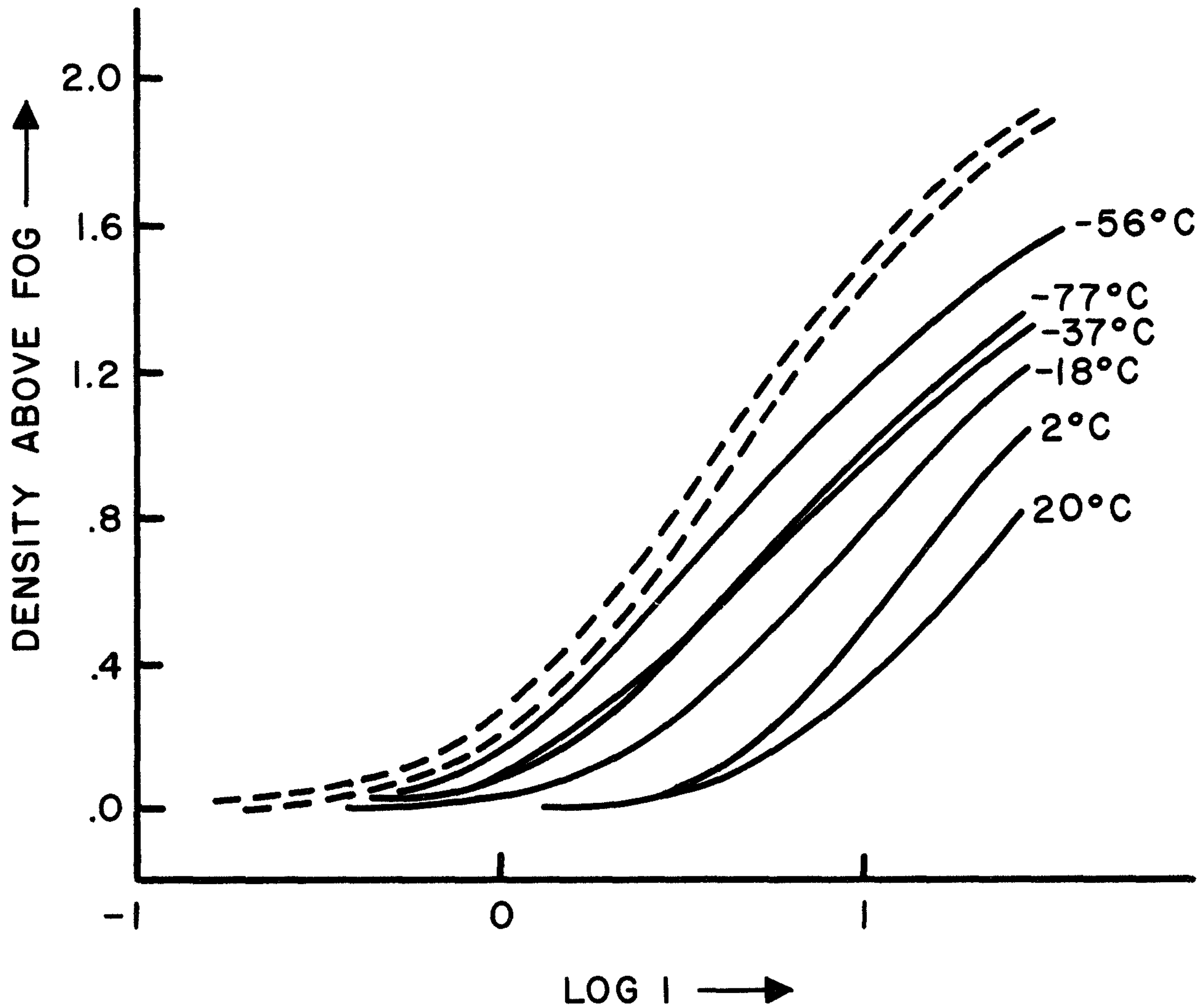

FIGURE 1 -- Characteristicscurves for Tri-X (solid lines) and 103a-0 (dashed lines) at various temperatures for λ=4400A and t=30 min.

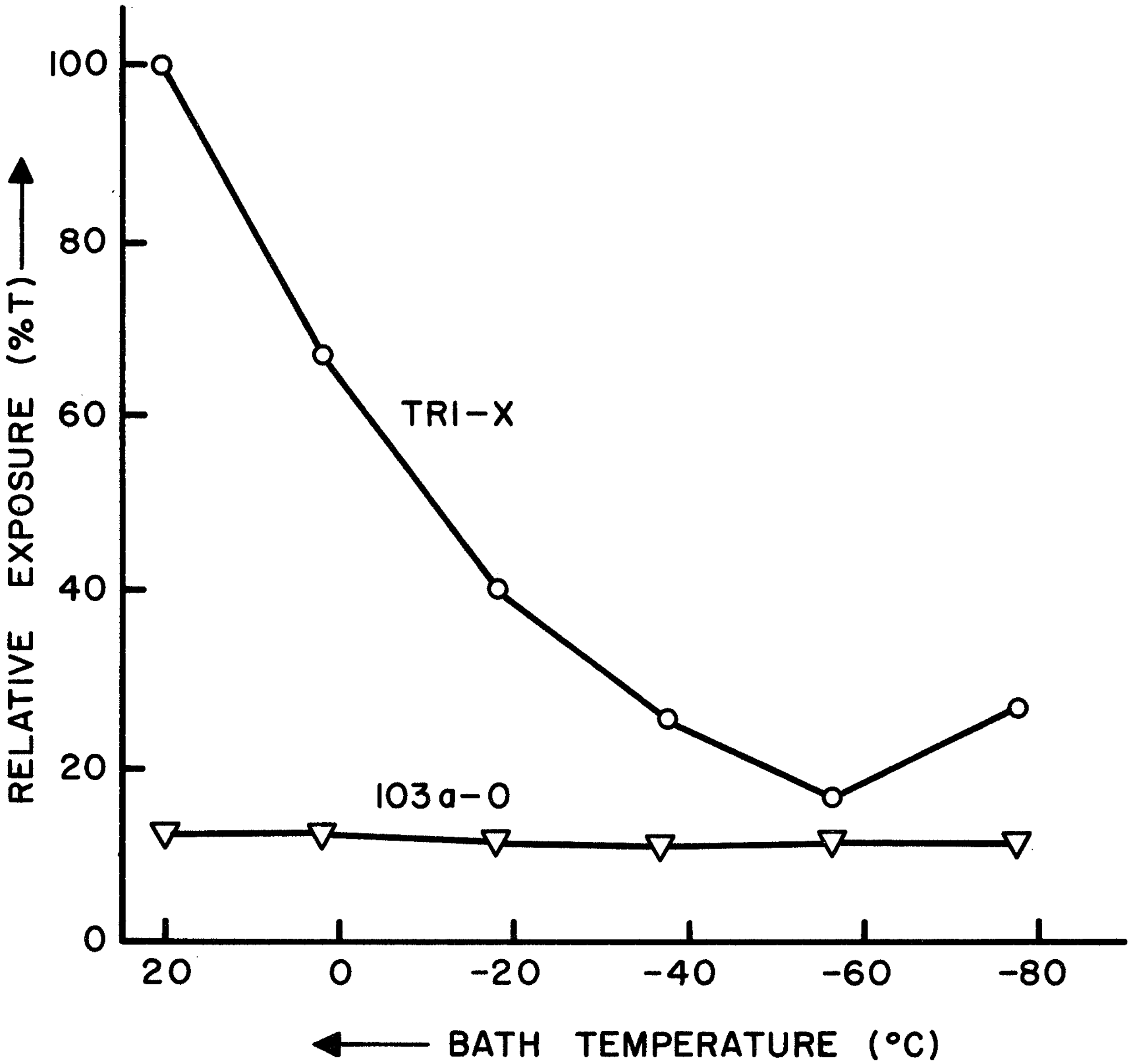

FIGURE 2 -- Relative exposure (in % transmission normalized to Tri-X at 20°C) needed to produce a density of 0.6 above fog as a function of bath temperature.