OPTIMUM CONDITION FOR DEVELOPEMENT OF SWR (II)

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(Received April 16, 1969)

Abstract

The optimum condition for developement of SWR film is determined by evaluating the graininess and the granularity of negatives. This is achieved by two methods; 1) the instrumental measurement and 2) the sensory test.

The present results and the previous results concerning the resolving power[1] suggest the optimum condition, when the Kodak D-19 developer is used, is as follows; concentration of the developer is 1/4 of the original specification and the temperature range is between 18°C and 20°C.

I. Introduction

Occasionally, the photographic techniques become of great importance in the measurement of the extreme ultraviolet radiation. In these cases, the accuracy of a measurement is greatly affected by the microscopic quality of negatives, such as resolving power, graininess, sharpness, recognition and others. Among them, the resolving power and the graininess (or granularity) are especially important characters, which depend not only on the nature of the emulsion but also on the developing conditions.

Emulsions for the extreme ultraviolet radiation, for examples those of Eastman Kodak SWR types or Pathè Kodak SC types, contain relatively or extremely small amount of gelatine to support the radiation sensitive material (AgBr grains), because it absorbs the ultraviolet radiation strongly. Accordingly, the layer of emulsion of these films is rather thin and weak. Furthermore, the developement affects more strongly on the qualities of the negative than on other sorts of emulsion.

The most widly used emulsion of this type, *i.e.* SWR, is indicated to be developed at 20°C for five minutes with the developer D-19 prepared according to the specification. It is generally said, however, that the indication is not the best. The previous result as to the resolving power[1] has also shown that this is true. Thus, the optimum developing condition is considered to be somewhat different from the indication.

In the present experiment, the graininess and the granularity have been measured under various conditions of developement in order to find the optimum one. The graininess and the granularity are the qualities related to the roughness of the image of the negative (or positive) picture in microscopic sense, and are defined psychologically and physically, respectively.

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II. Experimental Procedure

Specimens of SWR film piece exposed to a given quantity of light were developed always with fresh D-19 developer under the following thirty conditions;

temperature: 10°C, 15°C, 18°C, 20°C, 25°C
×
dilution: 1 : 0, 1 : 1, 1 : 2, 1 : 3, 1 : 4, 1 : 5,

where the dilution means the ratio of added water to original D-19, for example 1 : 2 dilution is 1 part of original D-19 with 2 parts of water.

Since the graininess (or granularity) depends reasonably on the film density[2], the developement was controlled so that all negatives have a equal density (say about D=1.0). Thus, thirty specimens were used for measurements.

1) Graininess

The sensory test has been done with 24 persons (panels) to estimate the graininess. Panels observed the image of the pattern of graininess magnified by a projector with variable magnification on the opal glass screen placed 3 meters apart from them. The panel calls the instant when she just clearly recognizes the grain on the screen, and the magnification M of the image is recorded. The value of graininess is thus defined as 1000/M.

2) Granularity

There are several methods to estimate the granularity[3)5)]. In the present experiment, the single spot scanning technique described by Selwyn[4] has been applied. Selwyn's constant, *i.e.* the granularity, is given as

$$G = \sigma_D \sqrt{A}, \qquad (1)$$

where σ_D is standard deviation of density on the negatives and A is the area of aperture of microdensitometer. The minimum aperture, 0.25 mm × 1.0 mm, of the microdensitometer used was, however, too large as compared with the average size (about 15 μ in diameter) of graininess. Accordingly, the 15.4 times maginfied positive of SWR on a Fuji Neopan F plate, which has relatively fine graininess, under a definite condition was used to measure the standard deviation of density. The resulting picture on the plate is a magnified pattern of SWR overlapped with the pattern of graininess of the plate, and is also affected by the procedures of printing. Thus, the measureable standard deviation of density may not be linealy related with the Selwyn's constant of SWR. This measureable quantity is, however, considered to be intimately related to the Selwyn's constant, so that they are able to serve as an evaluation of SWR granularities, furthermore of the each developing condition.

The standard deviation of density was estimated from a hundred points taken at regular intervals along an arbitrary segment on the plate. Three segments were measured for each plate, because SWR shows rather many flaws and spots, which may cause serious errors. The interval of two adjacent sampling points on a plate and the slit width of the microdensitometer correspond to 12.9 μ and 16.2 μ, respectively on the original SWR plate. They are comparable with the SWR graininess.

III. Results and Discussion

Experimental results of graininess and granularity are shown in Figs. 1 and 2.

The averages of them over temperatures for given dilution and over dilutions for given temperature are shown in Figs. 3 and 4, respectively. Two typical magnified photograph of specimens are given in Fig. 5.

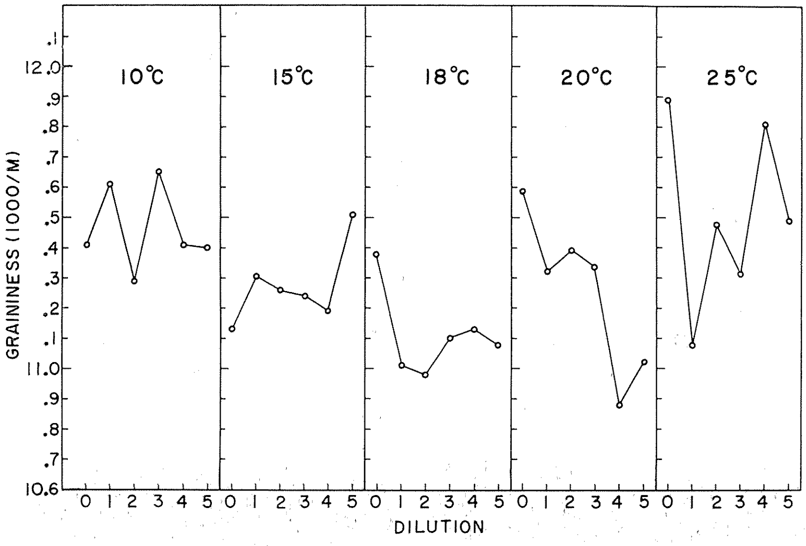


FIG. 1. The graininess for each condition of developement. Abscissa designates the ratio of added water to original D-19.

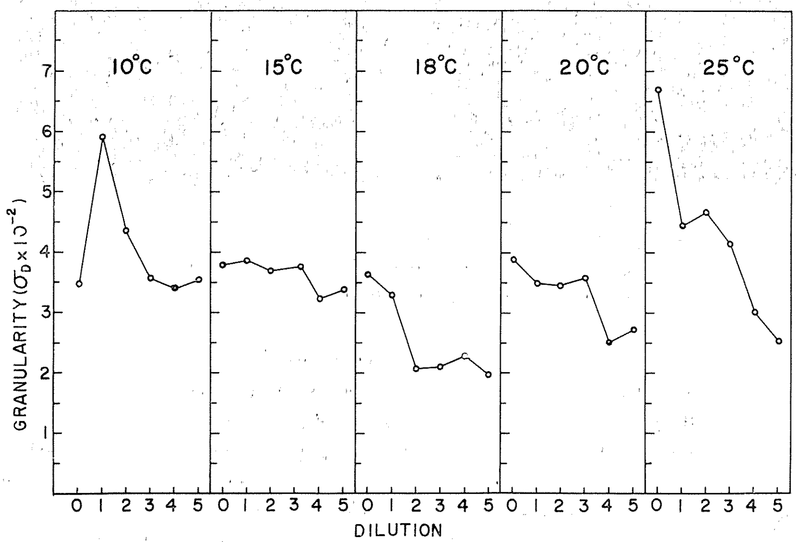


FIG. 2. The granularity for each condition of developement.

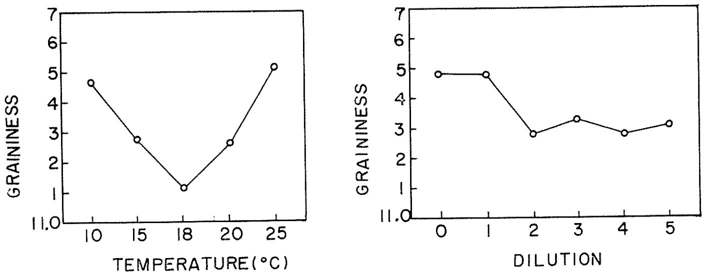


FIG. 3. The mean values of graininess.

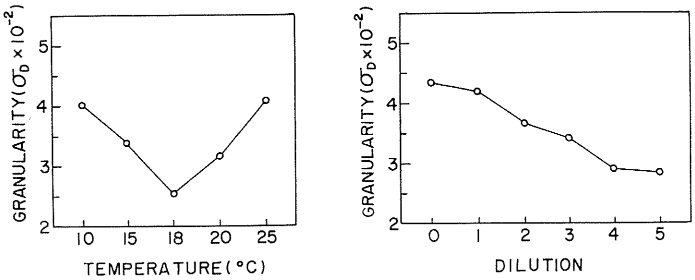
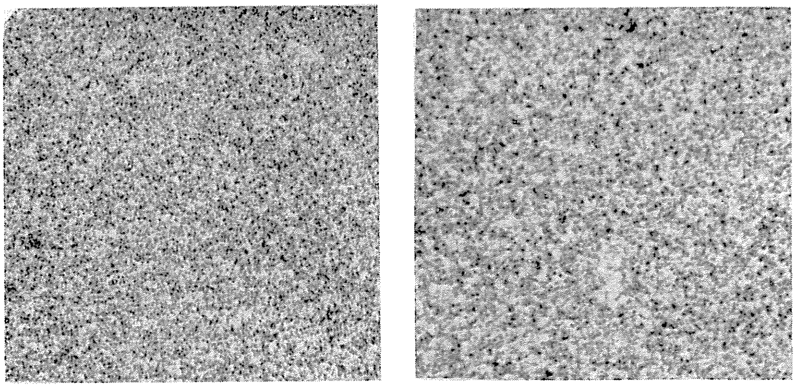


FIG. 4. The mean values of granularity.



a) b)

FIG. 5. Two photographs of typical specimene (×75).
a) Developed condition 18°C, 1 : 1 dilution.
b) Developed condition 25°C, 1 : 4 dilution.

It seems that these figures show the results as follows:

(1) As the temperature raises, the diluted developer gives better negatives.

(2) The specified condition (20°C, original developer) is not the best.

(3) When the temperature is too low, the granularity is rather deteriorated.

(4) The best negative is obtained when the concentration of developer is 1/4 of the original one and the temperature is 18°C.

The correlation coefficient between the grainiess and the granularity was 0.56. The errors of the present experiment is about ±10%. It is conceivable that the errors in graininess arise mainly from the fact that the insufficiency of the number of panels to average out the personal errors. On the other hand, the errors of granularity originate from the local inhomogeneity of the pattern of graininess. These will be improved by increasing the number of panels or the points of measurement on the plate.

IV. Conclusion

Although the accuracy of the experiment is not satisfactory, the best developing condition as to the graininess is almost consistent with that obtained from the granularity. Thus, it is reasonably concluded that, taking into consideration the previous result of the resolving power, the optimum condition for developement of SWR using D-19 developer is as follows:

(1) Temperature is kept between 18°C and 20°C.

(2) Concentration of the developer is about 1/4 to the original reagent.

In this case, the developing needs about 10 minutes. The prescription of the better developer is a subject of future study.

V. Acknowledgment

The authors wish to express their hearty thanks to Prof. K. Yoshihara for his kind advice and encouragement throughout this work. The authors would also like to thank the students of Sugiyama Women's Colledge for their help in sensory test.

VI. References

1) K. Okada and K. Kamiya, Memoirs of the Faculty of Engineering, Nagoya University, Vol. **19**, No. 2 (1967), 306.
2) S. Kikuchi, *et al.*, Kagakushashin-binran (I)—Science of Photography—, Maruzen, pp. 106.
3) S. Kikuchi, *et al.*, *ibid.* (II), pp. 446.
4) S. Kikuchi, *et al.*, *ibid.* (II), pp. 448.
5) H. Kubota, *el al.*, Shashinlens—Camera Lens—and Response function, pp. 68.