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PREPARATION AND EVALUATION OF SOME PIGMENTS TO BE USED IN AIRCRAFT PAINTS

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ABSTRACT:

Pigments are widely used in commercial compositions of plastics, rubbers, ceramics, printing inks, cosmetics and paints. The paints as surface coating compositions can be decorative or protective. In the field of aircraft, the outside finish must also protect against fluctuation of temperature, intense ultraviolet radiation and impact with raindrops at high velocity.
In this work a series of yellow to buff and blue to green pigments were prepared by the calcination process at 1100 C. Their spectral characteristics were measured and the relation between the absolute spectral data and wavelength of the incident radiation in the range of 400-1100 nm were given. The effect of percentage of pigment composition and the time of calcination were shown. The spectral data were measured for the pigments in powder and film forms. A discussion on the use of such inorganic pigments in the field of aircraft was reported.

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INTRODUCTION :

Paint is a fluid composition which, when spread over a surface in the form of a thin layer, will form a solid, adherent and cohesive film. This fluid paint contains three major ingredients: pigment, binder and thinner. In addition to these major ingredients, paint may contain small quantities of other components called additives such as : driers, antisettling agents, fungicides and others [1].

Pigments are chemical compounds, either organic or inorganic, that can be used to impart colour to paints in addition to other various commercial materials such as : ceramics, plastics, cosmetics and printing inks [2].

Pigments are and remain insoluble when applied in different surface coatings. They exhibit one or more of three basic functions : optical , protective and reinforcing ones. Colour, opacity and gloss are the most attracting optical functions. Weather stability, surface hardness, adhesion, flexibility and corrosion prevention can be considered as their participation in the protective function. The perfect selection of the pigment and the level of pigmentation can affect-to larger extent- the film`s cohesiveness, elasticity, hardness and abraison resistance which aid in the reinforcement of the surface film [3,4].

The performance of certain pigment depends on the pigment-binder system, its refractive index, particle shape and size distribution, and the efficiency of its dispersion in the medium[5].

In military applications, the surface coating compositions must also function to harmonize the object with each type of the expected operation ground, so that it cannot be easily detected by various means of observation and reconnaissance. These means act in different ranges of electromagnetic rays from the visible, near infrared to the far infrared rays. This main criterion is added to the great stability of colour, protection against corrosion, facility of use with safe handling, rapid drying and the durability of all these properties in the field service of variable humidity, temperature and wind [6,7].

In the presented work, some selected pigments of colours yellow to buff and blue to green were prepared and evaluated by their absolute spectral data in the wavelength range of 400 to 1150 nm.

EXPERIMENTAL

1- Chemicals :

All chemicals used in the experimental work were of the laboratory grade. They were : Chromium oxide green (Bakin), antimony trisulphide (Morgan), calcium carbonate (VEB); titanium dioxide (Bakin); cobaltous chloride (Prolabo) and aluminium oxide (BDH).

was sieved into two fractions of different grain size. The smaller grain size showed smaller reflectance throgh the total range of the wavelength, compared with that of the greater one.

These prepared compositions were relatively opaque and have good hiding power, and can be used to match the desert surroundings.

In the second group of cobalt aluminate blues, the main pigment was prepared from the blending of cobaltous chloride and aluminium oxide with molar ratio of 1:1 which was shown in Fig.4. The reflectance curve showed a rapid increase in the curve after about 650 nm. The reflectance in the near infrared region from 750 nm to 950 nm ranged between 6o to 65% and the maximum in the near infrared was reached at about 900 nm.

The addition of chromium oxide green to the last composition and its effect on the shape of the spectral curve was shown in Fig. 5. The reflectance curve was modified with the maximum shifted to about 975 nm. The effect of calcination time was shown in the same figure where as the time was raised from 1,5 hrs to 3 hrs the reflectance was increased by about 10 % all over the near infrared range with a relatively smaller effect in the visible range. These type of pigments can be used to match the agricultural surroundings.

In the field of aircraft application, it is well known that subsonic types of aircraft have a basic structure of aluminium alloy with high-tensile steel and magnesium alloys for certain specialized parts. The best selection of the binder system for such structural alloyis the epoxy - polyamide system in both primer and finish. This selection of binder system and the last mentioned pigments was to resist the wide fluctuations of temperature ; intense ultraviolet radiation at high altitudes, and impact with raindrops at high velocity. This system of pigment - binder is also resistant to fuels and to hydraulic, brake and de-icing fluids. The temperature fluctuations can result in condensation of appreciable amounts of water inside the outer skin. This can boil at the temperature reached by the skin of some aircraft and is a potent source of corrosion. So this can be avoided by such selection of pigment-binder system in addition to the use of strontium chromate pigment in the primer.

Another modification in the binder is the use of polyurethane based on aliphatic isocyanate in the finish and the primer of epoxy-polyamide type, which give good gloss-retention, colour and chemical resistance.

With high-speed aircraft, the exposed temperatures are higher, the same system can be used. Acrylics being characterized by showing good colour stability at such temperatures, can be applied.
Two-pack epoxies are not favoured for the exterior of modern aircraft. They chalk rapidly at high altitudes where the ultraviolet raidation is more intense than at lower levels. The interior alloy surfaces can be finished in two-pack epoxy enamel

2- Procedure :

The two selected groups of the pigments were prepared from the corresponding chemical compounds capable of yielding the metal oxides through a calcination process at high temperature. The exact amount of each compound was accurately weighed. The compounds were , then, intimately blended together in a centrifugal ball mill for few minutes and after that the mixture was calcined at a temperature of 1100°C for two different periods of time : 1,5 and 3 hours. The pigment was ground to a fine powder and evaluated by its absolute spectral data in the wavelength range of incident radiation from 400 t0 1150 nm. The effect of calcination time, pigment composition and particle size distribution were measured.

3- Instruments:

The absolute spectral data were measured by an Optronic Infrared Spectroradiometer Model 746 equipped with an IBM computer and Hewelett plotter. The mixing and pulverizing of the pigment composition were executed by a Retsch centrifugal Ball Mill of type S1. The calcination was carried out in a thermostated Mufle furnace Model NABER 2804 Bremen acting up to 1200°C.

RESULTS AND DISCUSSIONS :

Two different groups of pigments were selected to be used in durable coatings, designed for exterior applications over a variety of substrate materials such as steel, aluminium and hardboard, and carrying long-term warranties. These pigments can be considered as alternatives after the restrictions and concerns over the use of the toxic lead-based yellow and cadmium - based pigments.

These two groups are of the types chrome-titanate buffs and cobalt aluminate blues. Because they are prepared via the calcination process yielding a crystals of mixed oxides, these pigments will be chemically inert that are not attacked by acids or alkalis, completely stable and heat resistant.

In the group of chrom-titanate buffs , the spectral curves shown in Fig. 1 indicates the effect of the composition of initial ingredients on the absolute spectral data, where in one composition titanium oxide was blended with a mixture of chrome green and antimony trisulfide. In the other, calcium carbonate was added to the mixture before calcination. There was no appreciable change in the reflectance of these two compositions with the tested ratio.

In Fig. 2 , the effect of calcination time of the previous composition was shown at 1,5 and 3 hrs. The spectral reflectance showed a small increase all over the range in the pigment of calculation time 3 hrs, compared with that of 1,5 hrs. The effect of the particle size was shown in Fig. 3. The prepared

after the surface pretreatment and priming.

CONCLUSION :

The selected groups of pigments can be widely used in the surface coating of aircraft. The two groups of pigments can match both the desert and the agricultural surroundings. They are resistant to high temperature, humidity and all chemicals since they ate prepared Via the calcination process. There is a wide range of colours that can be obtained by a slight change in the initial ingredients. These colours can be described by their specific spectral curves in the visible to the near infrared region of electromagnetic waves.

REFERENCES:

(1) Rothenberg, G.B., : "Paint Additives Recent Developments", Noges Data Corporation, 1978.

(2) Kirk Othmer : " Encyclopedia of Chemical Technology", John Wiley, 1981.

(3) Morgans, W.M., : "Outlines of Paint Technology, Vol. 2, John Wiley , 1984.

(4) Konstandt, F. , : "Organic Coatings, Properties and Evaluation", Chem. Publish. Co., 1985.

(5) Patton, T.C., : "Paint Flow and pigment Dispersion", John Wiley, 1979.

(6) Oil and Colour Chemicsts Association, Australia : "Surface Coatings", Vol 1 and 2 ; 2nd Ed., Chapman, 1983 and 1984.

(7) Hlunt R.W.G., : "Measuring Colour" , Ellis Horwood, 1987.

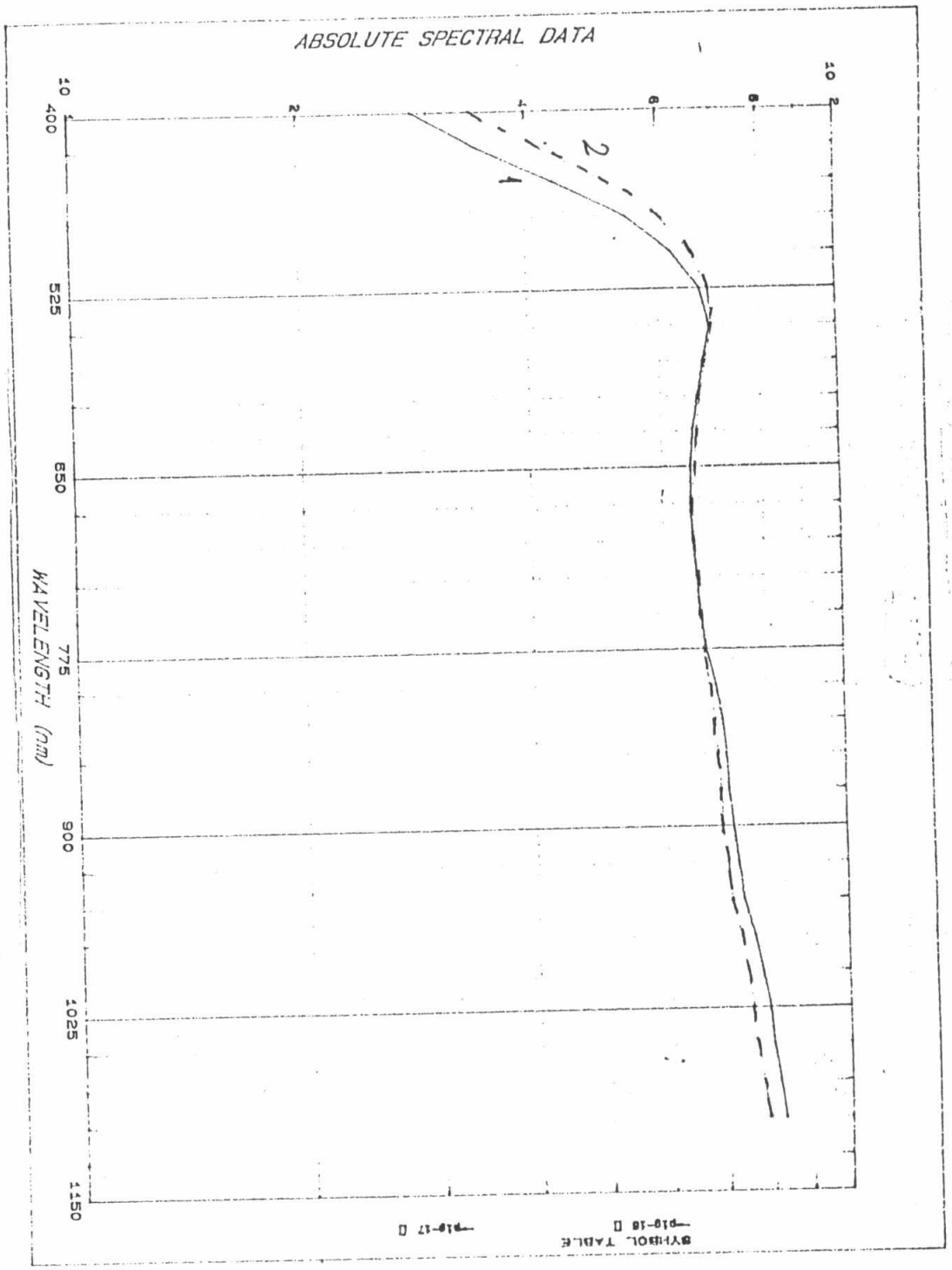

Fig.(1) : Effect of the initial composition of the pigment on the absolute spectral data :
(1) Cr_2O_3: Sb_2O_3 : CaCO3 (1.5 : 2.2 : 24.6)
(2) Cr_2O_3: Sb_2O_3:TiO_2: CaCO3(1.5 : 2.2 : 12.8 :15)

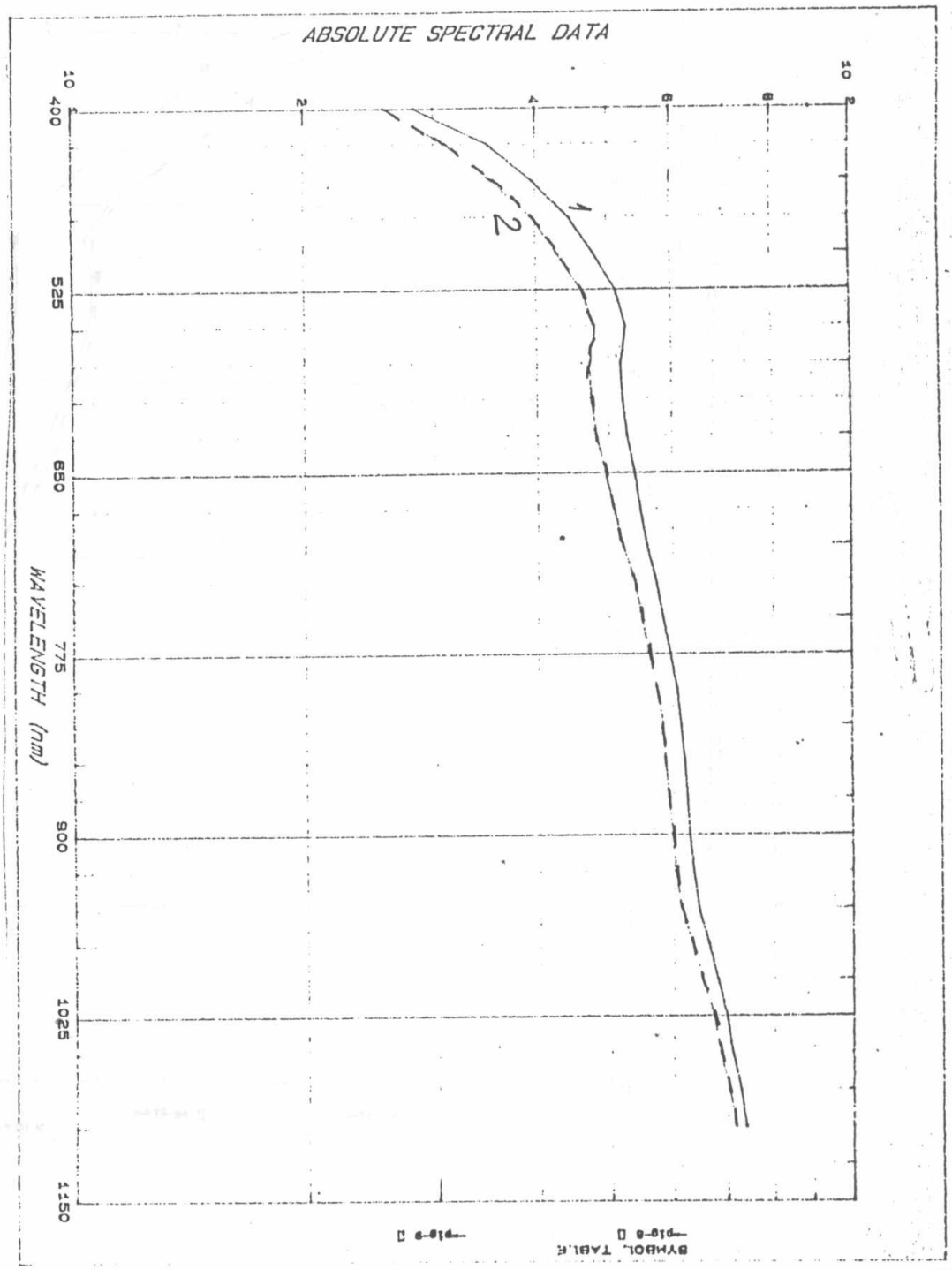

Fig.(2) : Effect of calcination time at 1100°C on the absolute spectral data of the composition. Cr_2O_3 : $SbSO_3$: $CaCO_3$: TiO_2(1.5 : 2.2 : 15 : 12.8) (1) 2.5 hrs. (2) 3 hrs.

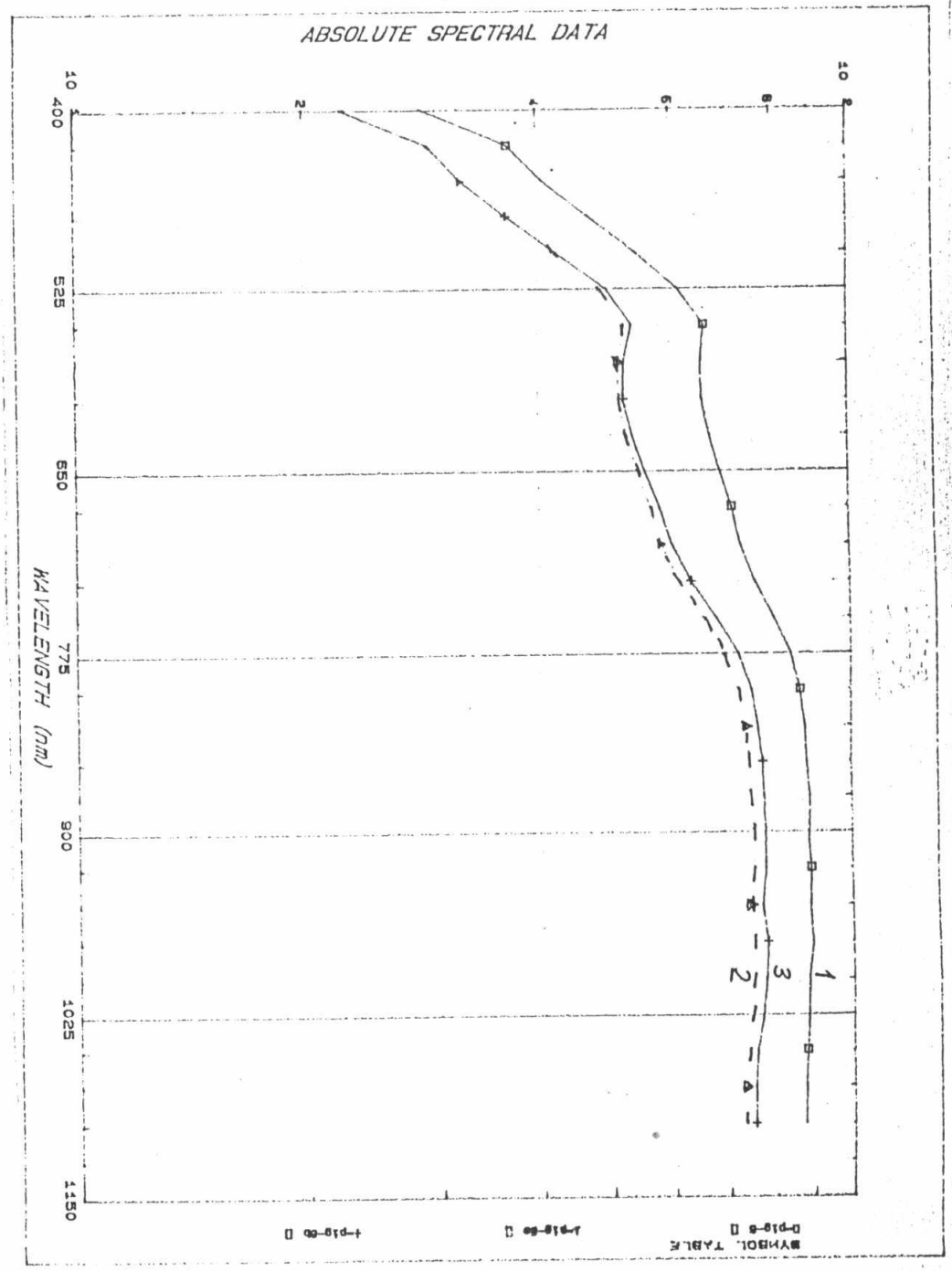

Fig.(8) : Effect of grain size on the absolute spectral data of the composition.
Cr_2O_3 : 8b2Sb : TiO_2 (4.5 : 2.2 : 24.5)

(1) Without sieving
(2) Smaller grain size
(3) greater grain size.

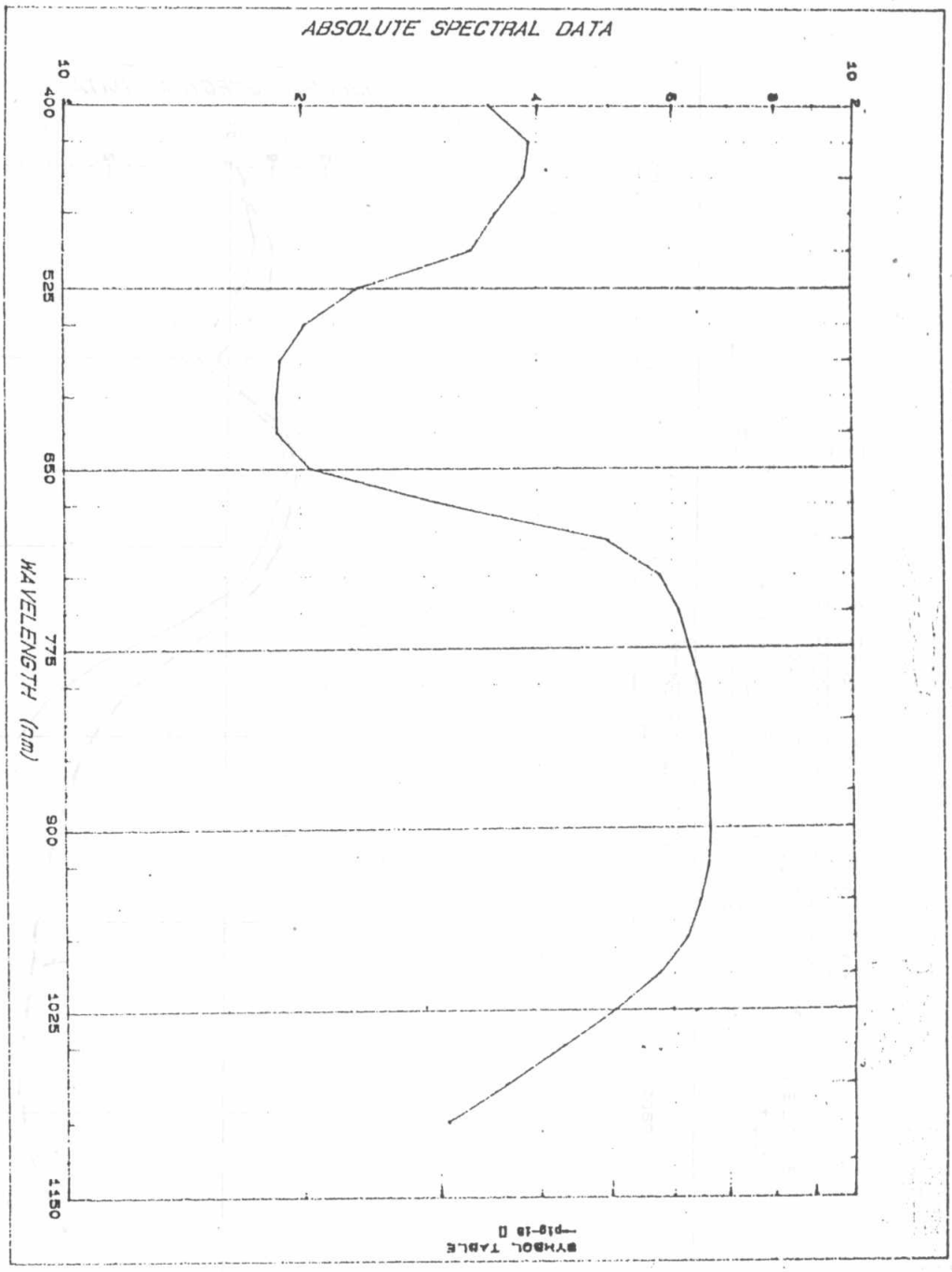

Fig.(4) : The spectral characteristics of the prepared cobalt aluminate blue of composition $CoCl_2$: Al_2O_3 (13 : 10.18) calcined at 1100°C for 3 hrs.

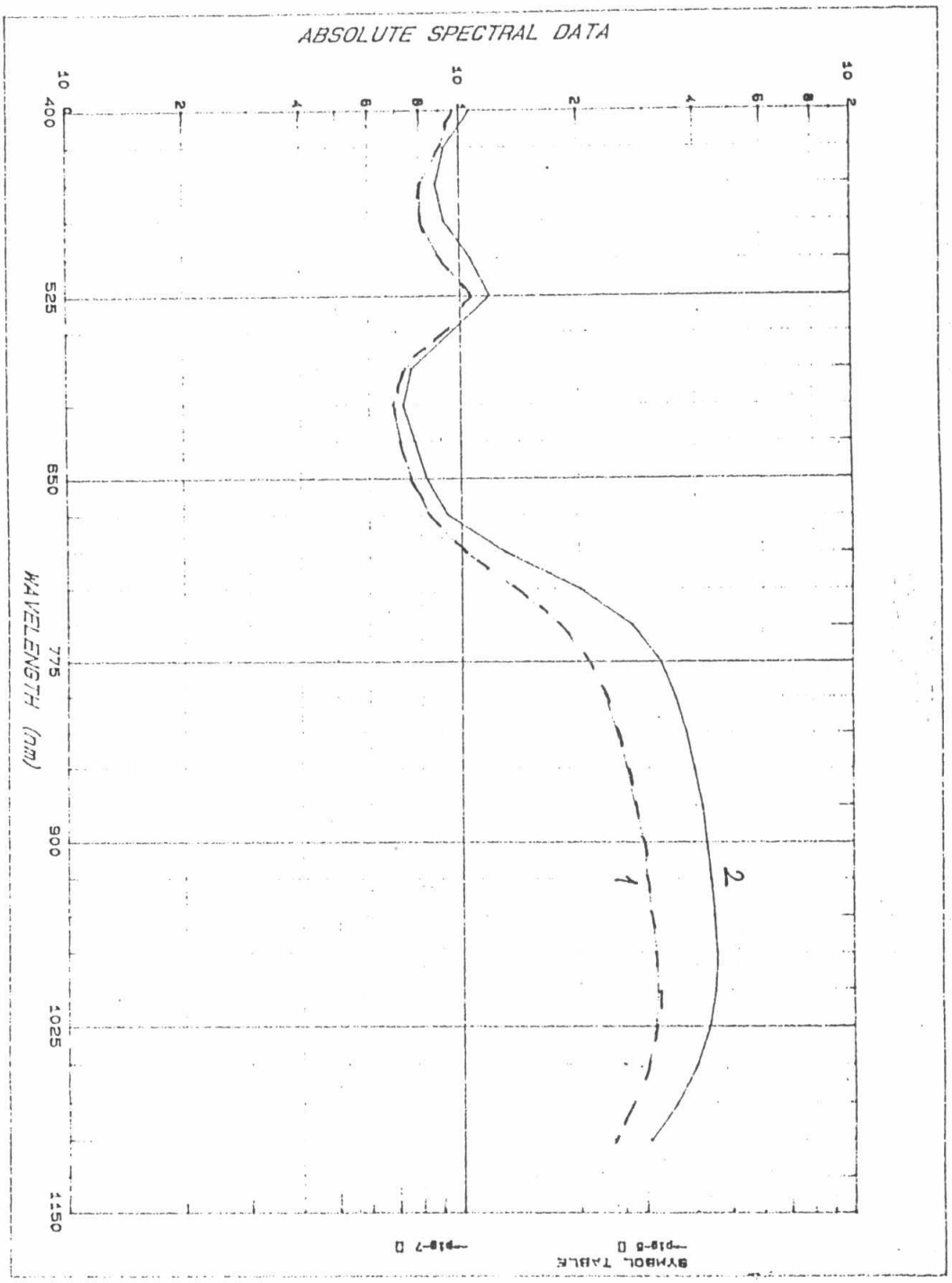

Fig.(5) : Effect of adding chromium oxide green to the prepared cobalt aluminate blue with molar ratio on the spectral characteristics.
(1) 1.5 hrs calcination at 1100°C
(2) 3 hrs calcination at 1100°C.