[Contribution from the Department of Chemistry, University of Cincinnati]

THE SYNTHESIS AND PROPERTIES OF DI-2,4-DIMETHYLPHENYLTHIOCARBAZONE

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The superiority of di-*beta*-naphthylthiocarbazone over diphenylthiocarbazone (dithizone) as a reagent in the determination of mercury and zinc is now well established (1, 2). Since the improvement clearly is due to the weighting effect resulting from the substitution of phenyl by naphthyl, it seemed likely that similar advantages might be secured by replacing the phenyl groups with substituted phenyl groups. Accordingly, in the present study, di-2,4-dimethylphenylthiocarbazone was synthesized and its analytical behavior explored.

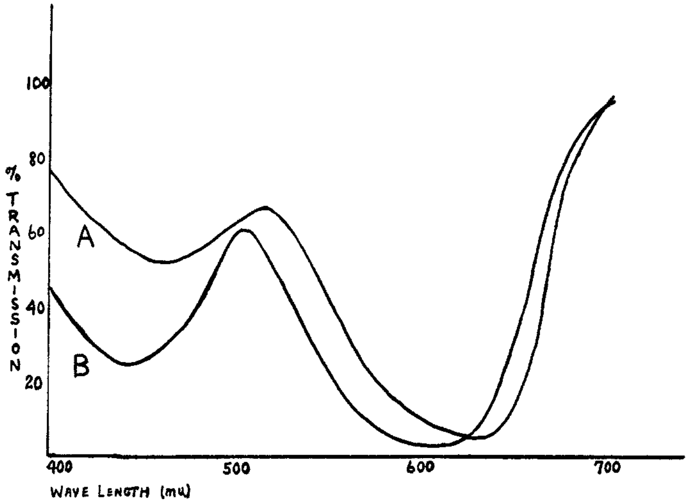


Fig. 1

A—Di-2,4-dimethylphenylthiocarbazone 7.5 micrograms/ml. $CHCl_3$.
B—Dithizone 10.0 micrograms/ml. $CHCl_3$.
Cell length—0.1 cm.

TABLE I

Color Comparison of the Various Metal Thiocarbazonates

	THIOCARBAZONE		
COLOR OF	DIPHENYL-(DITHIZONE)	DI-2,4-DIMETHYLPHENYL-	DI-*beta*-NAPHTHYL-
$CHCl_3$ soln.[a]	green	green-blue	blue-green
Hg Complex[b]	amber	orange	pink
Cd Complex	cherry red	red	violet
Zn Complex	pink	violet	violet
Bi Complex	orange	purple	magenta
Ag Complex	yellow	orange	—

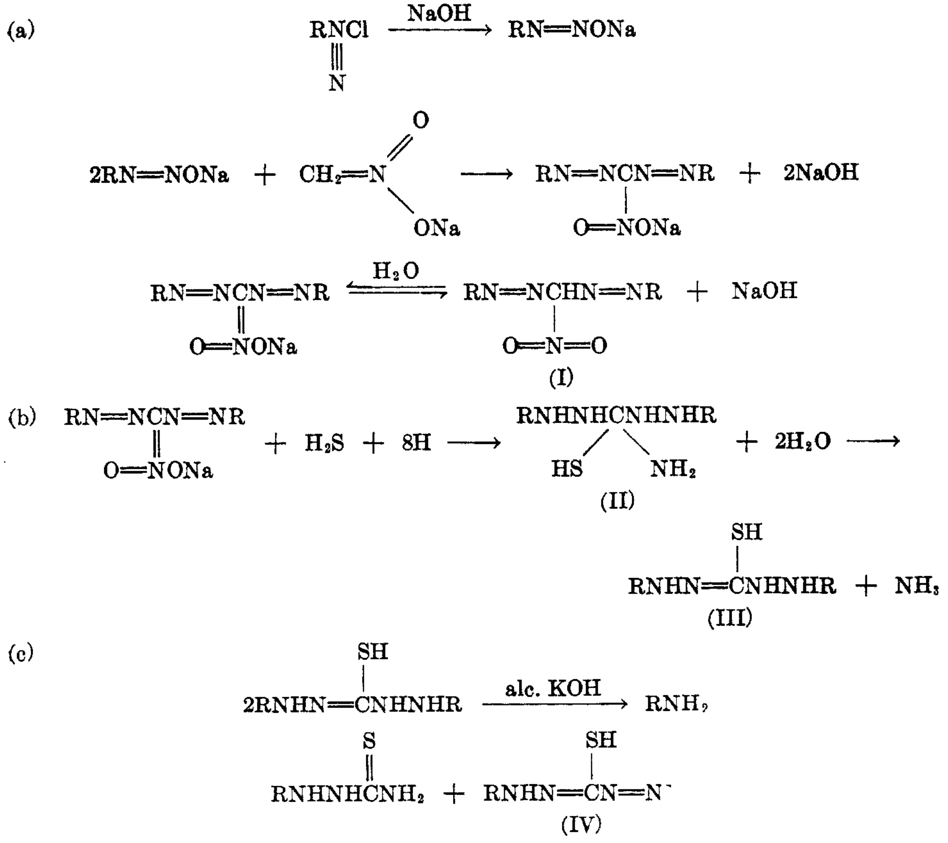
[a] Concentration of $CHCl_3$ solutions 0.001%.
[b] 10–20 micrograms of metal ions was used.

As expected, the properties of this new reagent lie between those of dithizone and di-*beta*-naphthylthiocarbazone. The transmittancy curve (Figure 1) is similar to that of dithizone but is slightly displaced toward longer wave lengths. The colors of its metal complexes are intermediate between those of the corresponding diphenyl- and dinaphthyl- thiocarbazonates (see Table I).

The shade and intensity of its metal derivatives present no inducement for introducing the new compound into analytical practise. However, the experimental confirmation of its predicted properties and the experience gained in its preparation justify the publication of the results of this investigation, since the findings may be of value in future studies of this group of extremely useful reagents.

The compound was prepared by a procedure that approximates the method used by Hubbard (3) to produce the di-*beta*-naphthyl derivative. Careful attention to purity of reagents and close maintenance of the prescribed conditions are essential to success in producing any of the thiocarbazones in satisfactory yield and purity.

The synthesis involves three steps: namely, production of (a) the nitroformazyl compound; (b) the thiocarbazide; (c) the thiocarbazone. These steps can be represented:



(a)

$$\underset{\underset{N}{|||}}{RNCl} \xrightarrow{NaOH} RN{=}NONa$$

$$2RN{=}NONa + CH_2{=}N\!\begin{array}{l}/\!\!/O\\ \backslash ONa\end{array} \longrightarrow \underset{\underset{O=NONa}{|}}{RN{=}NCN{=}NR} + 2NaOH$$

$$\underset{\underset{O=NONa}{\|}}{RN{=}NCN{=}NR} \overset{H_2O}{\rightleftharpoons} \underset{\underset{O=N=O}{|}}{RN{=}NCHN{=}NR} + NaOH$$

(I)

(b)

$$\underset{\underset{O=NONa}{\|}}{RN{=}NCN{=}NR} + H_2S + 8H \longrightarrow \underset{HS\diagup\;\diagdown NH_2}{RNHNHCNHNHR} + 2H_2O \longrightarrow$$

(II)

$$RNHN{=}\overset{\overset{SH}{|}}{C}NHNHR + NH_3$$

(III)

(c)

$$2RNHN{=}\overset{\overset{SH}{|}}{C}NHNHR \xrightarrow{alc.\ KOH} RNH_2$$

$$RNHNH\overset{\overset{S}{\|}}{C}NH_2 + RNHN{=}\overset{\overset{SH}{|}}{C}N{=}N^{\cdot}$$

(IV)

EXPERIMENTAL

(a). *The nitroformazyl compound.* Four and eight-tenths ml. of sodium hydroxide solution (25 g./100 ml.) is diluted with 13.5 ml. of absolute alcohol and 1.6 ml. (0.03 mole) of freshly distilled nitromethane added. The mixture is cooled to −5° and the crystals which separate are dissolved by adding 100 ml. of ice-water. The solution of alkaline nitromethane is kept at −5° until used.

2,4-Dimethylaniline, 7.25 g. (0.06 mole), is rapidly mixed with 15 ml. of hydrochloric acid (sp. gr. 1.18) and 25 ml. water. The solid mass of hydrochloride crystals is cooled to 0°, and slowly diazotized (vigorous stirring) by the addition of 5 g. of sodium nitrite dissolved in 10 to 15 ml. of water. The resulting amber solution (filtered if necessary) is transferred to a 250-ml. beaker, immersed in acetone, and cooled by addition of Dry Ice to this acetone bath. If desired, Dry Ice can be added directly to the diazotized solution. The latter is cooled to −10°, and then 40 ml. of sodium acetate solution (40 g. $NaOAc \cdot 3H_2O$/100 ml. solution) is added dropwise (mechanical stirring). The mixture is kept at −5°.

The alkaline nitromethane solution is now treated with 4.8 ml. of the sodium hydroxide solution, placed in a separatory funnel containing cracked ice, and dropped slowly, with stirring, into the diazotized solution. The nitroformazyl compound (I) separates at once as an orange precipitate, which darkens somewhat on standing. The strong tendency to form tar is minimized by keeping the temperature low, by waiting long enough for the nitrogen oxides to escape after diazotization, and by employing pure nitromethane. After 30 minutes, the precipitate is filtered with suction and washed thoroughly with ice-water. (If the product is tarry the filtration is slow and the washing with water may be omitted.) The precipitate is transferred to a beaker, stirred with 50 ml. of 50% acetic acid, filtered with suction and washed, first with 10% acetic acid and then with water. The air-dried product is boiled with 150 ml. of absolute alcohol. The bright red residue is washed with 10 ml. of hot alcohol and dried. The average yield from 7.25 g. of 2,4-dimethylaniline is 2 g. of the nitroformazyl compound. Larger proportions may be used to carry out the reaction if desired.

TABLE II

PROPERTIES AND ANALYSES OF DI-2,4-DIMETHYLPHENYLTHIOCARBAZONE AND INTERMEDIATES

	COLOR	MELTING POINT °C.	ANALYSES	
Nitroformazyl	red	145–148	Nitrogen	Calc'd 21.37
				Found 21.40
Thiocarbazide	yellow	168–171		—
Thiocarbazone	blue-black	152–154	Sulfur	Calc'd 10.26
				Found 10.50

(b). *The thiocarbazide.* Ten g. of the product from (a) is placed in a wide mouth bottle with 100 ml. of absolute alcohol. Dry ammonia gas is passed through the cooled suspension for 15 to 25 minutes. Hydrogen sulfide is then passed into the suspension (mechanical stirring if desired). Visible reduction starts in about 30 minutes and then proceeds quickly. The end of the reaction is signalled by the disappearance of the red formazyl compound and the deposition of light yellow crystals (II). The contents of the flask are then treated with an equal volume of water to produce the thiocarbazide (III) which is filtered off. More water is sometimes necessary to complete the precipitation, as the product is fairly soluble in alcohol.

(c). *The thiocarbazone.* The unstable thiocarbazide compound is oxidized at once to the thiocarbazone by the addition of 20 ml. of 5% alcoholic potassium hydroxide. A clear dark red solution forms. It is drained off and neutralized by pouring into a liter of approximately 0.2 normal hydrochloric acid. The resulting blue-black precipitate is filtered off and air dried.

The method employed for purifying dithizone (4) cannot be used because di-2,4-dimethylphenylthiocarbazone, like the *beta*-naphthyl derivative, is insoluble in ammonia. The impure carbazone (IV) can be purified by dissolving it in chloroform, washing the solution with water, and then precipitating the product by adding absolute alcohol. An average yield of 0.3 g. of pure carbazone was obtained per gram of crude material purified.

Nitrogen analyses were carried out by the Dumas combustion method. Attempts to use the standard and modified Kjeldahl procedure were not successful as part of the nitrogen is lost. The thiocarbazide, because of its instability, was not analyzed. For analytical data and properties of the compounds prepared see Table II.

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