

3 minutes. The device is described here for use especially in those instances in which the purchase or construction of the common motor-driven homogenizer with a special blown glass or stainless steel pestle (2) is not practicable.

An assembly suitable for grinding 8–10 g of tissue can be made in the following manner. A section of soft pure gum tubing 22 mm in diam, 45 mm long, with a 9-mm bore, is cemented to a glass rod 9 mm × 300 mm, with a rubber adhesive used for joining rubber to hard surfaces.

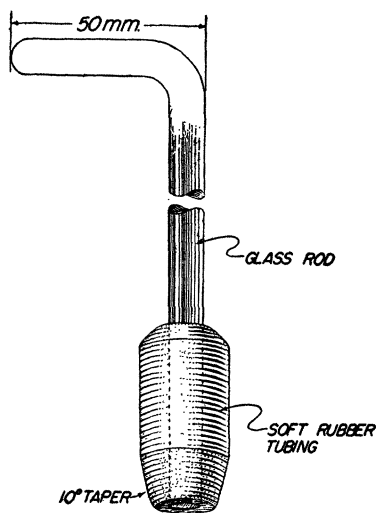


FIG. 1.

The plunger is used with a thick-walled test tube 22 mm × 160 mm. To aid in trapping pieces of tissue between the plunger and the wall of the test tube, the plunger is tapered or rounded on a grinding wheel or sanding belt (Fig. 1), and the inner wall of the test tube is roughened with moderately fine emery paper. Thorough homogenization is obtained even without the taper and roughening of the glass, although occasional small bits of tissue may not be broken up. A comfortably snug fit between plunger and test tube is easily obtained by selecting the appropriate diameter of rod and by taking advantage of the normal variation in test tube diameter. Homogenizers of various sizes have been made successfully with different types of pure gum tubing.

Homogenization is carried out by placing tissue pieces of about 3 mm in their longest dimension in the test tube, adding the dilution medium, and grinding with a motion as in washing a test tube with a brush. For sterile preparations the homogenizer can be autoclaved and the glass rod manipulated through a sterile cotton plug (1).

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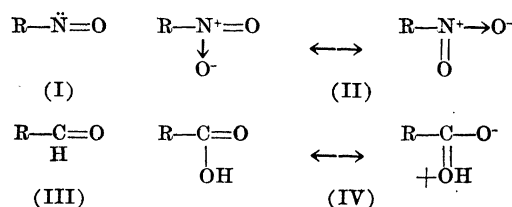
Certain Physical Properties of Some Substituted Diphenyl Sulfones and Sulfoxides

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It is a well-known fact that sulfones, as a class, are extremely stable substances. The oxygen is so firmly attached that its removal is usually impossible without further disruption of the molecule. On the other hand, the sulfoxides, which are in the next lower scale of oxidation, are quite reactive toward a variety of chemical reagents. They are easily oxidized to sulfones and reduced to sulfides.

These differences in chemical behavior between the two types of sulfur compounds in different states of oxidation seem to parallel, in a general way, the differences which exist between certain nitrogen compounds differing in oxidation state. The nitroso compounds (I) (lower state of oxidation) are much more reactive chemically than the nitro compounds (II). The nitroso compounds undergo addition reactions to the nitrogen-oxygen multiple bond, are easily oxidized and reduced, and display a willingness to undergo chemical changes not shown by the nitro compounds. The parallelism also exists among certain carbon compounds. Aldehydes (III), for example, possess much of the reactivity of nitroso compounds (I) and again differ from the acids (IV) by a carbonyl activity that is repressed in the acids.

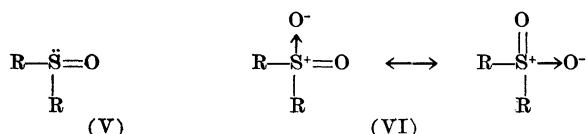


This reactivity is again noticed in the relatively facile addition to the aldehyde carbonyl group, its easy oxidation and reduction, etc.

The present widely accepted explanation for the relative stability of nitro compounds and carboxylic acids (or carboxyl anions) is that the structures are resonating and actually do not possess true multiple and coordinate covalent linkages but rather contain linkages which are the result of hybridization of the two. The lower oxidized forms, on the other hand, are considered to demonstrate the presence of true multiple linkages.

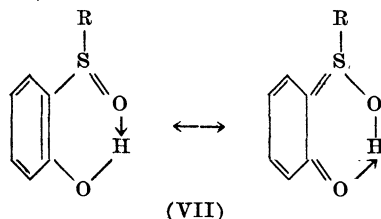
If one extends this line of reasoning to the sulfoxides and sulfones, it is apparent that the sulfoxides should owe their chemical reactivity to the presence of a sulfur-oxygen double bond (V). Here neither sulfur nor oxygen is charged as in the coordinate covalent representation

¹We are glad to acknowledge our indebtedness to Miss Elizabeth Peterson of the Department of Chemistry, University of Illinois, who determined the infrared spectra.



and a single pair of electrons remains unshared on the sulfur atom. During oxidation to the sulfone, this pair presumably forms a coordinate covalent with an oxygen atom. The establishment of the coordinate bond creates a unit positive charge on the sulfur and a unit negative charge on the oxygen. In order that these charges may approach a minimum, a neutralization occurs and resonance results. The final structure (VI) then closely approaches that of the nitro group and the carboxylic anion. The chief advantage of the resonating decet shell representation for sulfone sulfur over and above the octet and dodecet formulas is that it draws a sharp distinction between sulfoxides and sulfones, and secondly that it permits a simple and rational explanation for the stability of sulfones.

It was believed that if the sulfur-oxygen bond had appreciable double-bond character the effect on neighboring groups should be of a recognizable type. For example, in *o*-hydroxydiphenyl sulfoxide (IX, Table 2), the interaction of the hydroxyl and sulfoxide groups might conceivably lead to the establishment of a new resonating system (VII).



The formation of such a resonating chelate structure would be apparent by a marked shift in the characteristic absorption band of the hydroxyl group in the infrared region, and by at least a partial fixation of the double-bond system of the benzene ring.²

If sulfone oxygen atoms are of the type indicated in (VI), one would expect the chelation in *o*-hydroxydiphenyl sulfone (VIII₁, Table 2) to be weaker than in the corresponding sulfoxide (IX, Table 2) with the result that the infrared spectrum of the sulfone should show an OH absorption peak less displaced toward longer wavelengths from the position (approx. 3615–3625 cm⁻¹) characteristic of nonbonded OH groups in simple phenols. As expected, the *o*-hydroxydiphenyl sulfone (VIII₂, Table 2), when examined as a solid suspension in Nujol, showed a sharp OH peak whose center could be accurately located at 3557 cm⁻¹.³ However, the OH band of the sulfoxide

² We are now examining the rearrangement of 2-hydroxy-4-allyloxydiphenyl sulfone and sulfoxide and the diazonium coupling of 2,4-dihydroxydiphenyl sulfone and sulfoxide to determine whether bond fixation exists.

³ Hilbert, G. E., *et al.* (3) examined the IR spectrum of 2-naphthol-1-sulfone in dilute solution in carbon tetrachloride and found no hydroxyl absorption in the region of the first overtone. This was taken to indicate that both hydroxyl groups are bonded to the sulfone group.

(IX, Table 2), under the same conditions, was so far displaced toward longer wavelengths as to merge almost completely with the C-H absorption, making its exact location impossible to determine. Because, as will be shown, both these compounds are essentially monomeric, there can be no doubt that the intramolecular interaction is vastly greater in the sulfoxide than in the sulfone.

Since the magnitude of the hydroxyl shift in the sulfoxide approximates that found in corresponding carbonyl compounds, it provides a powerful argument for the existence of a double bond between sulfur and oxygen in that structure. The only alternative, which is a coordinated

TABLE 1
MOLECULAR WEIGHTS IN NAPHTHALENE

Compound	Molality	Observed mol. wt	α^*	Formula weight
VIII ₁				234.3
	.0480	235.7	1.006	
	.0960	235.4	1.005	
	.1437	237.8	1.015	
	.2177	241.5	1.031	
	.2889	244.6	1.044	
	.3595	247.5	1.057	
	.4617	251.7	1.074	
	.5356	254.7	1.087	
VIII ₂				234.3
	.04725	280.8	1.199	
	.09286	317.4	1.355	
	.1643	368.4	1.572	
	.2404	417.9	1.784	
	.3357	477.7	2.039	
	.4062	517.1	2.207	
	.4998	568.2	2.425	
	.5939	615.5	2.627	
IX				218.3
	.05179	213	0.974	
	.09887	219	1.01	
	.1438	223	1.02	
	.1892	224.6	1.029	

$$\alpha^* = \text{Association factor} = \frac{\text{observed mol. wt.}}{\text{formula wt.}}$$

oxygen, may be dismissed as being entirely inadequate to explain the observed result.

The displacement observed with the hydroxy sulfone likewise appears to be too large to be explainable by means of coordinated oxygens. This effectively disposes of the octet shell for sulfur in sulfones. The displacement, however, is not great enough to allow one to write two doubly bonded oxygens, since this type of structure should have the same, or nearly the same, effect on the hydroxyl shift as was observed in the sulfoxide. The dodecet formulation appears therefore to be quite inadequate in this regard also. There remains only the decet, and we have already stated cogent reasons for believing this to be of a resonating type.⁴

In order to be able to interpret the spectra more clearly and to determine more exactly the quantitative aspects of chelation versus association in hydroxy sulfones, we have determined the molecular weights of the isomers

⁴ Toussaint (4) has likewise proposed the resonating decet shell for sulfone sulfur as an explanation of the observed x-ray spectra of derivatives of diphenyl sulfone.

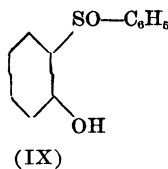
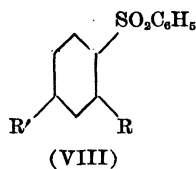
VIII₁ and VIII₂, and of compound IX cryoscopically in naphthalene.⁵ These data, shown in Table 1, illustrate the striking difference between the isomers, and the very considerable extent of group interaction. It is hardly to be doubted that molecular weight determinations on other similar pairs would afford comparable results. The monomeric nature of *o*-hydroxydiphenyl sulfoxide is also demonstrated.

As a means of detecting chelation or association in the remaining compounds listed in Table 2 we have used the convenient and reliable method of wet melting point de-

TABLE 2

Compound	Melting point in °C		Depression in °C
	Dry	Wet	
VIII			
1. R=OH, R'=H	96-98	83.5	12.5
2. R=H, R'=OH	135-136.2	84	51
3. R=OH, R'=OCH ₃	114-115.4	103.5	10.5
4. R=OCH ₃ , R'=OH	167-170	116	51
5. R=H, R'=OCH ₃	90-90.6	80	10
6. R=OCH ₃ , R'=H	141-142	125	16
7. R=R'=OCH ₃	119-119.5	103	16
8. R=NH ₂ , R'=H	118-120.5	107	11
9. R=H, R'=NH ₂	166-172	133.5	32.5
10. R=NH ₂ , R'=OCH ₃	126-127.5	113	13
11. R=OCH ₃ , R'=NH ₂	130-131	102	28
IX	162-164	159	3

pression.⁶ These materials were synthesized partly as intermediates and also to provide the basis for the further study of related compounds.



It is apparent from the data in Table 2 that both the hydroxyl group and the amino group are capable of significant interaction with the sulfone group. When the interacting groups are *para*, the result of interaction is association of molecules, whereas when they are *ortho*, the result is the establishment of a chelated structure which would be expected to be essentially monomeric. Hence, when the *para* isomer is melted in the presence of moisture, the polar water molecules become bonded with the sulfone group, displacing the phenolic hydroxyls (or amino groups) and thereby breaking up the associated complex. In the case of the *ortho* isomer, it appears that water molecules are bound but, due to the absence of polymeric units, the effect is relatively minor. This interpretation seems to be indicated because of the behavior of the methoxy sulfones, which also suffer melting point depressions when wet. Since *p*-hydroxydiphenyl sulfoxide was

⁵ Details of the apparatus and method employed will be discussed fully in a forthcoming paper by one of us (I. M. H.).

⁶ The use of the comparison of wet and dry melting points to distinguish between chelation and association has been well established by the work of Baker (1) and Hunter (2).

not available for study, no comparison with the *ortho* isomer can be made, but the very small depression of this isomer indicates strong chelation.

A more complete account of the experimental details of this work will be published elsewhere.

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Abundance of N¹⁵ in the Nitrogen Occluded in Radioactive Minerals

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The presence of elementary nitrogen in the gases occluded by uranium minerals was established by Hillebrand's (3) analyses of uraninites and pitchblendes from diverse localities. This discovery was overshadowed by the detection of helium in these minerals by Ramsay (5). Subsequent investigation of pitchblende from Katanga, Belgian Congo, and of a uraninite crystal from Keystone, South Dakota, by Davis and Kennedy (1) revealed the presence of nitrogen as well as helium. Analyses of the occluded gases showed the presence of 0.159% helium by weight and 0.075% nitrogen in the pitchblende, and about 0.03% of each in the uraninite.

In an investigation of the occluded gases in radioactive minerals by means of the mass spectrometer, we have detected nitrogen and helium in the fraction isolated by ignition of the samples and remaining uncondensed in a liquid air trap. The isotopic ratio of N¹⁵ to N¹⁴ in these samples was invariably higher than in samples of atmospheric air or in nitrogen isolated from nitrogenous compounds.

The gases were isolated by heating the freshly ground minerals to a bright red heat for several hours in a quartz tube sealed through a graded seal to the gas inlet system of the mass spectrometer. To eliminate interference with the nitrogen peaks at masses 28 and 29 by the carbon monoxide peaks at the same masses, the liberated gases were passed through a U-tube containing I₂O₅ maintained at 145° C to oxidize any carbon monoxide that might be present. Water, carbon dioxide, and oxides of sulfur, liberated by the thermal decomposition of the mineral and its associated gangue, were separated by means of two liquid air traps. The gases not condensed in the liquid air traps were analyzed from mass 12 through mass 44 in all of the samples and from mass 4 to mass 90 in many of them. The mass spectra showed a high percentage of helium, a trace of methane, and from 5% to 10% nitrogen by volume. No attempt was

¹ We wish to express our appreciation to W. F. Foshag and E. P. Henderson of the U. S. National Museum for providing us with certain of the specimens used in this work.