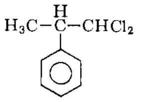
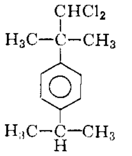
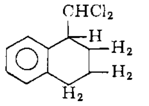
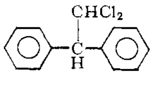
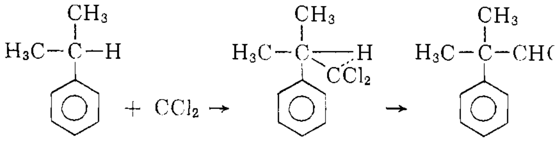
TABLE I

REACTION PRODUCTS OF AROMATIC HYDROCARBONS WITH DICHLOROCARBENE

		Yield,	B.p.			Analyses, % (Calcd.) (Found)			
Hydrocarbon	Product	%	°C.	mm.	n^{20}D	C	H	Cl	Mol. wt.[a]
Ethylbenzene		17	57	0.4	1.5351	57.1	5.3	37.6	189
						56.8	4.9	38.0	189
p-Diisopropylbenzene		24	81	0.2	1.5279	63.6	7.3	29.0	245
						63.4	7.0	29.3	245
Tetralin		39	110–111	0.9	1.5648	61.4	5.6	33.0	215
						61.1	6.3	33.3	215
Diphenylmethane		17	120–125[b]	0.5		66.9	4.8	28.3	251
						66.7	4.6	28.5	251

[a] By mass spectrometry-weighted average of four isotope peaks. [b] Solidified; m.p. 78–79°; M. Delacre, *Bull. soc. chim.*, (3) **13**, 858 (1895), gives m.p. 80° for this compound made from dichloroacetaldehyde, benzene, and aluminum chloride.

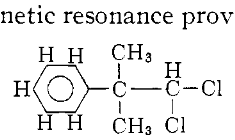
Dichlorocarbene has now been found to react with alkyl-substituted aromatic hydrocarbons to give insertion products that have been identified by elemental analysis and infrared, nuclear magnetic resonance, and mass spectrometry. The reaction with cumene to give β,β-dichloro-t-butylbenzene is typical



A mixture of 1131.2 ml. (8 moles) of cumene, 556.7 g. (3 moles) of sodium trichloroacetate, and 75 ml. of 1,2-dimethoxyethane was stirred and refluxed until no more CO_2 evolved (12 hours). The mixture was filtered, the sodium chloride was washed with hexane, and the combined filtrate and hexane washings were distilled. Cumene, 750.8 g. (6.3 moles), was recovered, then β,β-dichloro-t-butylbenzene was distilled at 68–70° and 3 mm. A total of 199 g. (0.98 mole) was obtained, n^{20}D 1.5400. This was a 33% yield based on sodium trichloroacetate.

Anal. Calcd. for $C_{10}H_{12}Cl_2$: C, 59.0; H, 5.9; Cl, 35.0. Found: C, 58.8; H, 5.7; Cl, 35.3.

Nuclear magnetic resonance proved the structure



The sample was run neat, with hexamethylsiloxane as 0. The 6-methyl hydrogens gave a sharp peak at 8.64 τ, the peak for the lone hydrogen of the dichloromethyl group was at 4.38 τ, and that for the five hydrogens on the benzene ring at 2.87 τ. The relative areas were 6:1:5. Mass-spectrometric analysis was wholly consistent with the proposed structure, β,β-dichloro-t-butylbenzene. There was a strong parent peak at 202 and at the isotope masses; the major fragment on decomposition was formed by loss of $CHCl_2$. The infrared absorption spectrum was similar to that of t-butylbenzene; it had strong bands at 10.5, 11.7, 12.9, and 13.8 μ that were not present in t-butylbenzene. Reduction with sodium and alcohol gave t-butylbenzene boiling at 168–170°, n^{20}D 1.4920, whose infrared spectrum was identical with that of an authentic sample.

Under the same conditions, other hydrocarbons gave the products shown in Table I.

Best yields resulted when the dichlorocarbene was generated by thermal decomposition of sodium trichloroacetate[4]; by comparison, reaction of cumene with chloroform and potassium t-butoxide[1] or sodium methylate and ethyl trichloroacetate[5] gave only 0.5 and 5% yields of dichloro-t-butylbenzene, respectively. The additional thermal energy is evidently needed for the insertion reaction: the mechanism may not be identical with the normal carbene insertion mechanism.

All of the dichloromethyl compounds, except that from diphenylmethane, are new; synthesis by any other route would be difficult.

---

(4) W. M. Wagner, *Proc. Chem. Soc.*, 229 (1959).

(5) W. E. Parham and E. E. Schweizer, *J. Org. Chem.*, **24**, 1733 (1959).

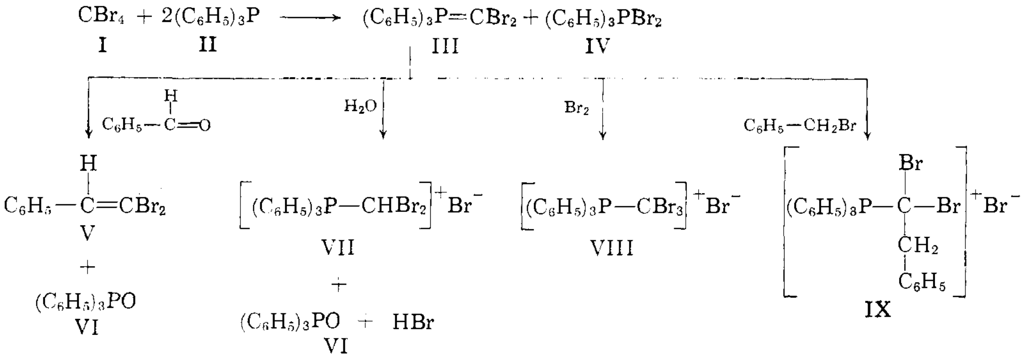
RESEARCH DEPARTMENT
AMOCO CHEMICALS CORPORATION
WHITING, INDIANA
ELLIS K. FIELDS

RECEIVED MARCH 15, 1962

A NEW SYNTHESIS OF 1,1-DIBROMOÖLEFINS *via* PHOSPHINE-DIBROMOMETHYLENES. THE REACTION OF TRIPHENYLPHOSPHINE WITH CARBON TETRABROMIDE

Sir:

When triphenylphosphine (II) (0.1 mole) was added to a well stirred solution of carbon tetrabromide (I) (0.05 mole) in *dry* methylene chloride (250 ml. distilled from P_2O_5) an orange solution

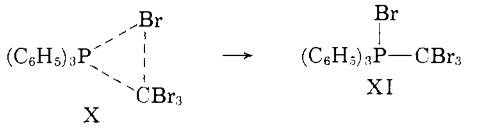


was obtained. The infrared spectrum of this solution showed a band at 8.4 μ, which is characteristic of phosphine-methylenes. Addition of benzaldehyde (0.05 mole) caused fading of the color. No carbonyl absorption in the infrared was detectable after 5 minutes. The solution was washed with water, the solvent was removed, and the residue was extracted with hexane. Triphenylphosphine oxide (VI, 0.1 mole) was filtered off and the hexane extract was distilled, giving β,β-dibromostyrene[1] (V) (11.0 g., 84% yield); b.p. 76–78° (0.2 mm.); n_D^{25} 1.6350; strong band at 11.5 μ (CCl_4). Calcd. for $C_8H_6Br_2$: C, 36.7; H, 2.3; Br, 61.1; found: C, 36.4; H, 2.3; Br, 61.1.

Dibromomethyltriphenylphosphonium bromide[2] (VII) was obtained in quantitative yield when water was added to the methylene chloride solution containing one mole of carbon tetrabromide and two moles of triphenylphosphine.

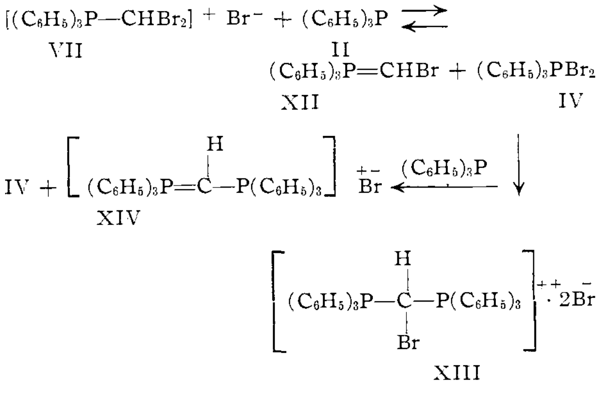
The sparingly soluble, colorless, tribromomethyltriphenylphosphonium bromide (VIII, 9.3 g.) separated out when bromine (3.0 g.) in methylene chloride (8 ml.) was added to a solution containing carbon tetrabromide (6.62 g.) and triphenylphosphine (10.5 g.) in methylene chloride (70 ml.). VIII had m.p. 246–247° (nitromethane); calcd. for $C_{19}H_{15}PBr_4$: C, 38.4; H, 2.5; Br, 53.9. Found: C, 38.4; H, 2.9; Br, 52.5.

The reaction of triphenylphosphine with carbon tetrabromide involves an attack by phosphorus on bromine, possibly as depicted in X and leading directly to an intermediate with pentavalent phosphorus, XI. Reaction of XI with a second molecule of the phosphine would generate triphenylphosphine-dibromomethylene III. The methylene chloride solution remains clear, although the tribromomethylphosphonium salt VIII is sparingly soluble.



The scope of this new bromoölefin synthesis could be extended through further reactions of the phosphinedibromomethylene, for instance III → IX, above. Benzyl bromide (1.71 g.) was added to a solution containing carbon tetrabromide (3.32 g.) and triphenylphosphine (5.24 g.) in dry methylene chloride (60 ml.). After 4 hr. at reflux temperature, the solution was washed with aqueous sodium bicarbonate. Removal of solvent gave 2.7 g. of benzene-soluble triphenylphosphine oxide and 5.2 g. of benzene-insoluble (1,1-dibromo-2-phenyl)-ethyltriphenylphosphonium bromide (IX); m.p. 171–172° (methylene chloride–diethyl ether); calcd. for $C_{26}H_{22}PBr_3$: C, 51.6; H, 3.6; Br, 39.5. Found: C, 51.8; H, 4.2; Br, 39.3. The reaction of these α,α-dibromoalkylphosphonium salts with triphenylphosphine and other reagents will be described elsewhere.

Triphenylphosphine (II) reacts rapidly with dibromomethyltriphenylphosphonium bromide (VII) in methylene chloride by attack of phosphorus on bromine. If this reaction is carried out in wet methylene chloride, the products, after 5 minutes, are bromomethyltriphenylphosphonium bromide, $[(C_6H_5)_3P\text{-}CH_2Br]^+Br^-$, and triphenylphosphine oxide. When two moles of triphenylphosphine and one mole of the dibromomethylphosphonium salt (VII) dissolved in dry methylene chloride were kept for 20 hr. at reflux temperature, *in the dark*, the product was methylidebis-(triphenylphosphonium) bromide[3] (XIV, *ca.* 80%); the scheme shown is plausible but omits possible acid-base equilibria.[3]



Although the intervention of phosphoranyl free radicals[2] seems well established for the reaction of triphenylphosphine with bromoform, the present observations and previous ones[3] strongly suggest that free radical processes may not be general in

---

(1) J. U. Nef, *Ann.*, **308**, 310 (1899).

(2) F. Ramirez and N. McKelvie, *J. Am. Chem. Soc.*, **79**, 5829 (1957).

(3) F. Ramirez, N. B. Desai, B. Hansen and N. McKelvie, *ibid.*, **83**, 3539 (1961).

the reaction of tertiary phosphines with polyhalomethanes.[4]

---

(4) Acknowledgment is made to the Donors of the Petroleum Research Fund administered by the American Chemical Society (Grant 286-A), and to the National Cancer Institute of the National Institutes of Health (Grant CY-4769) for support of this research.

(5) Alfred P. Sloan Fellow, 1961–1963.

DEPARTMENT OF CHEMISTRY FAUSTO RAMIREZ[5]
STATE UNIVERSITY OF NEW YORK
LONG ISLAND CENTER N. B. DESAI
OYSTER BAY, N. Y. N. MCKELVIE

RECEIVED FEBRUARY 22, 1962

EFFECT OF SOLVENT ON THE OPTICAL ROTATORY DISPERSION OF UNCHARGED MOLECULES CONTAINING THE PEPTIDE GROUP[1]

Sir:

It has been reported[2,3] that the optical rotatory dispersion of many native globular proteins does not resemble the optical rotatory dispersion of polypeptides with an α-helical structure, and that the change in going from a native to a denatured state is not the change expected for a helix-coil transition. In terms of the Moffitt–Yang equation[4,5]

$$\frac{3}{n^2+2}\cdot\frac{M_0}{100}[\alpha] = \frac{a_0\lambda_0^2}{\lambda^2-\lambda_0^2} + \frac{b_0\lambda_0^4}{(\lambda^2-\lambda_0^2)^2} \quad (1)$$

it is found that typical right-handed α-helical structures have $b_0 \simeq -650°$ (with λ_0 assigned a value of 212 mμ), whereas unfolded structures have $b_0 \simeq 0$. In the many "non-helical" globular proteins, by contrast, b_0 is close to zero in both native and unfolded states. Only a_0 changes when the protein becomes denatured.

A possible explanation of these results is the existence of a specific structure, as yet unidentified, which all "non-helical" proteins have in common. An alternative suggestion[2] is that no particular structure is needed to account for the observed results: that the difference between the optical rotation of native and denatured proteins may be partly (sometimes entirely) a quasi-solvent effect, reflecting the fact that the peptide groups of the native protein are largely in the interior of the globular structure, whereas in an unfolded conformation they are in a medium consisting largely of water.

A necessary part of any proof for such a hypothesis is a demonstration that the optical rotatory properties of *independent* peptide groups depend strongly on the solvent. We have accordingly made measurements, in a variety of solvents, on several simple molecules which contain peptide groups. Only uncharged molecules were used, so that changes in state of ionization (which are known to have important effects on the optical rotation of amino acids and small peptides) cannot occur.

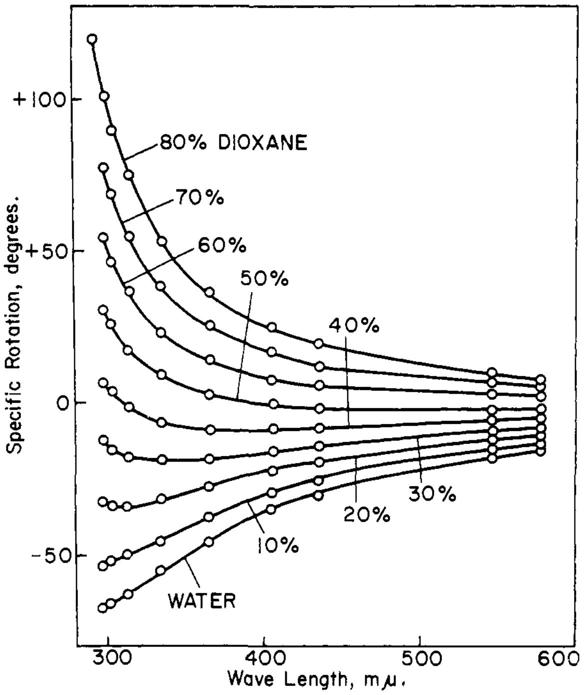


Fig. 1.—Optical rotatory dispersion of N-acetyl-L-glutamic acid, at 25°, in dioxane–water mixtures. Concentration of dioxane is per cent·by volume. A Rudolph spectropolarimeter, with a mercury lamp as light source, was used.

The results of one such study are shown in Fig. 1, which gives the measured rotation for N-acetyl-L-glutamic acid in mixtures of dioxane and water. It is seen that a striking solvent effect is indeed observed. When the data are plotted according to equation 1, with λ_0 = 212 mμ, the values of a_0 and b_0 given in Table I are obtained. A change in solvent is seen to influence a_0 but not b_0. The total

TABLE I

PARAMETERS OF THE MOFFITT-YANG EQUATION[a] (Degrees of Rotation)

		a_0	b_0
Ac-L-Glu[b]	In water	−165	+67
	In 10% dioxane	−140	+62
	In 20% dioxane	−113	+65
	In 30% dioxane	− 89	+68
	In 40% dioxane	− 60	+67
	In 50% dioxane	− 28	+67
	In 60% dioxane	+ 6	+64
	In 70% dioxane	+ 35	+66
	In 80% dioxane	+ 64	+67
β-Lactoglobulin[c]	Native	−169	−66
	Denatured	−623	−77
γ-Globulin[d]	Native	−280	0
	Denatured	−600	−20

[a] Using λ_0 = 212 mμ. The dispersion of refractive index was taken into account in the calculations of this paper. [b] Ac-L-Glu = N-acetyl-L-glutamic acid. [c] Ref. 2. [d] C. Tanford, C. E. Buckley III, P. K. De and E. P. Lively, *J. Biol. Chem.*, **237**, 1168 (1962).

---

(1) This work was supported by research grant G 17477 from the National Science Foundation, and by research grant A-4576 from the National Institute of Arthritis and Metabolic Diseases, U. S. Public Health Service.

(2) C. Tanford, P. K. De and V. G. Taggart, *J. Am. Chem. Soc.*, **82**, 6028 (1960).

(3) B. Jirgensons, *Tetrahedron*, **13**, 166 (1961).

(4) W. Moffitt and J. T. Yang, *Proc. Nat. Acad. Sci., U. S.*, **42**, 596 (1956). In this paper this equation is to be regarded as purely empirical.

(5) In equation 1, $[\alpha]$ is the rotation at any wave length λ, M_0 the molecular weight (in proteins it is the molecular weight per residue), n the refractive index of the solvent, and λ_0 an absorption wave length, which has been assigned a value of 212 mμ in this paper. The parameters a_0 and b_0 are derived from experiment.