

New Potent Diphenyl Ether Herbicides

Structural modification of the previously known diphenyl ether herbicides has resulted in new analogs (2-chloro-4-trifluoromethylphenyl 4-nitrophenyl ether and 2-chloro-4-trifluoromethylphenyl 3-ethoxy-4-nitrophenyl ether) which are unex-

pectedly tenfold more active for weed control, and possess potential commercial agricultural utility in soybean, cotton, peanuts, sunflower, wheat, and rice and for total weed control.

Diphenyl ethers have been established as commercial herbicides since the introduction of nitrofen and fluorodifen in the mid-1960's (Ashton and Crafts, 1973; Wegler and Eue, 1970), and a broad range of analogs is reported in the patent literature. This preliminary communication describes new diphenyl ethers which are at least ten times more active than the above herbicides and which exhibit a modified spectrum of activity and greater versatility of application.

EXPERIMENTAL SECTION

Synthesis of Compounds. *2-Chloro-4-trifluoromethylphenyl 4-Nitrophenyl Ether (RH-2512).* RH-2512 was prepared by the treatment of 3,4-dichlorobenzotrifluoride with potassium phenoxide in sulfolane at 170° overnight followed by nitration of the resultant 2-chloro-4-trifluoromethylphenyl phenyl ether in ethylene dichloride with a mixture of 2.4 equiv of nitric acid and 2.45 equiv of sulfuric acid for 10–20 min at 10°. The product, 2-chloro-4-trifluoromethylphenyl 4-nitrophenyl ether was recrystallized from isopropyl alcohol to give faintly yellow needles, mp 67–70°. Overall yields are about 60%. Anal. Calcd for $C_{13}H_7ClF_3NO_3$: C, 49.16; H, 2.22; Cl, 11.16; F, 17.94; N, 4.41. Found: C, 49.31; H, 2.15; Cl, 11.15; F, 17.80; N, 4.44.

2-Chloro-4-trifluoromethylphenyl 3-Ethoxy-4-nitrophenyl Ether (RH-2915). RH-2915 was prepared by treating a solution of 2 equiv of 3,4-dichlorobenzotrifluoride and 1 equiv of resorcinol in sulfolane with a solution of 2 equiv of potassium hydroxide in a minimum quantity of water at 150–160° and heating the resulting mixture at this temperature overnight. The product, 1,3-bis(2-chloro-4-trifluoromethylphenoxy)benzene was nitrated with mixed acids at 10–30° for 15–20 min to give 1,3-bis(2-chloro-4-trifluoromethylphenoxy)-4-nitrobenzene which after recrystallization from isopropyl alcohol had mp 110–111.5°. Treatment of the nitro compound in dioxane with excess potassium hydroxide in a small volume of ethanol for 2 hr at 45° followed by quenching with water and extraction yielded RH-2915, mp 83–84°, in an overall yield of about 40–50%. Anal. Calcd for $C_{15}H_{11}ClF_3NO_4$: C, 49.80; H, 3.07; N, 3.87; Cl, 9.80; F, 15.75. Found: C, 49.85; H, 3.33; N, 3.68; Cl, 9.90; F, 15.51. Structural assignment for the position of the nitro group in RH-2915 vs. the possible 6-nitro isomer was based on spectral comparison with the latter compound independently prepared.

Biological Testing. Testing for herbicidal activity was carried out using routine greenhouse procedures. Seeds were planted in flats in soil composed of $\frac{3}{4}$ silt loam top soil and $\frac{1}{4}$ sand. The compounds dissolved in acetone were sprayed on soil at rates of 0.1 to 8.0 kg/ha and the flats subirrigated in the greenhouse. Thirteen species employed were: barnyard grass (*Echinochloa crus-galli*), coffee weed (*Sesbania spp.*), dayflower (*Commelina communis*), downy brome (*Bromus tectorum*), foxtail (*Setaria viridis*), jimsonweed (*Datura stramonium*), nightshade (*Solanum nigrum*), quackgrass (*Agropyron repens*), ragweed (*Ambrosia artemisiifolia*), teaweed (*Madia elegans*), velvetleaf (*Abutilon theophrasti*), wild carrot (*Daucus carota*), and wild mustard (*Brassica kaber*). After 14 days the treatments were evaluated on a 0 (no effect) to 10 (plants dead) scale relative to an untreated check. Treatments

were duplicated; 26 individual values were averaged to obtain an overall value.

RESULTS AND DISCUSSION

The structures of RH-2512 and RH-2915 are compared with those of the known herbicides fluorodifen and nitrofen in Figure 1.

The new compounds provide a high degree of weed control (Table I). At 0.25 kg/ha, RH-2915 gave 95% and RH-2512 gave 60% weed control while nitrofen and fluorodifen required 2–8 kg/ha for similar weed control. A greater than ten times increase in activity with a minor modification in the structure of the chemical is evident. This increase in activity will reduce significantly the amount of chemical farmers will apply to the field each year and consequently can reduce the possibility of contamination in the environment.

In addition to the degree of activity, the spectrum of activity of the new compounds is broader than that of the old compounds nitrofen and fluorodifen. Many nitrofen-tolerant species, e.g. ragweed, and fluorodifen-tolerant species, e.g. velvetleaf, are much more sensitive to the new compounds (Table II). The two new compounds appear to have utility for preemergence weed control in such crops as soybean, cotton, peanuts, sunflower, rice, and wheat, at rates up to 0.25–1.0 kg/ha.

Applications of the commercial products nitrofen and fluorodifen are made either preemergence or postemergence to the crop or the weeds. In preemergence treatment, the compound is applied onto the surface of the soil. Incorporation of these compounds into the soil drastically reduces their effectiveness as herbicides. In greenhouse tests, the preemergence activity of the new compounds was not significantly affected by soil incorporation.

It is well established that nitrofen and other ortho-substituted diphenyl ether herbicides require light for activation (Matsunaka, 1969). Greenhouse studies have shown that RH-2915 and RH-2512 also require light and that activity tends to be higher in the field than the greenhouse, possibly because of greater light availability.

The acute oral LD₅₀ of RH-2915 is greater than 5000 mg/kg for male albino rats and mongrel dogs, and for RH-2512 it is 1000–2500 mg/kg for male albino rats and >5000 mg/kg for mongrel dogs. The acute dermal LD₅₀ of RH-2915 is >10,000 mg/kg for albino rabbits and for RH-2512 it is >5000–10,000 mg/kg.

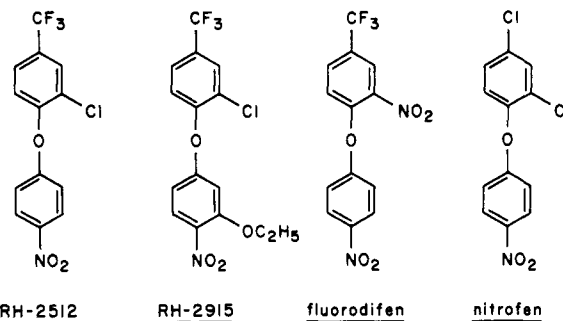


Figure 1. Herbicidal diphenyl ethers.

Table I. Degree of Herbicidal Activity of the New and Known Diphenyl Ether Herbicides^a

Dosage, kg/ha	Percentage control							
	RH-2512		RH-2915		Nitrofen		Fluorodifen	
	Pre ^b	Post ^c	Pre	Post	Pre	Post	Pre	Post
0.125	57	43	94	95				
0.25	76	54	97	99				
0.5	87	60	99	100				
1.0	96	98	100	100	61	53	46	41
2.0					75	72	60	42
4.0					81	66	67	44
8.0					85	78	73	50

^a For the description of the test system, see text. ^b Pre = preemergence. ^c Post = postemergence.

Table II. Spectrum of Preemergence Activity of Selected Weed Species^a

Species	Percentage control at dosage, kg/ha							
	RH-2512		RH-2915		Nitrofen		Fluorodifen	
	0.25	1.0	0.25	1.0	1.0	4.0	1.0	4.0
Coffeeweed	80	100	95	100	50	75	65	98
Jimsonweed	50	98	95	100	15	50	0	0
Ragweed	40	99	85	100	0	0	0	75
Velvetleaf	100	100	100	100	99	99	0	0
Wild carrot	0	30	100	100	0	0	0	0
Cotton	0	0	0	0	0	0	0	0
Peanuts	0	0	0	0	0	0	0	0
Rice	0	30	20	30	0	25	0	40
Soybean	0	0	0	0	0	0	0	2
Sunflower		0		0	0	0	0	
Wheat	20	70	20	20	0	50	0	30

^a For the description of the test system, see text.

ACKNOWLEDGMENT

The authors are indebted to H. O. Bayer for his contribution to this work and to J. D. Fisher and V. A. Musco for their assistance in laboratory and greenhouse work.

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Received for review October 31, 1974. Accepted January 20, 1975.