phenyls are used in the plastics industry, and their persistence in the environment is giving cause for concern; it may be possible to select those with the desired properties and still be biodegradable.

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Cinnamic Acid and *p*-Coumaric Acid, Precursors of Ubiquinone in Higher Plants, Green Algae and Fungi

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Previously we have reported on the incorporation of *p*-hydroxybenzoic acid into ubiquinone by the higher plants maize and French bean, the green algae *Euglena gracilis* and *Ochromonas danica*, the moulds *Agaricus campestris* and *Phycomyces blakesleeanus*, and the yeast *Saccharomyces cerevisiae* (Whistance, Threlfall & Goodwin, 1967; Spiller, Threlfall & Whistance, 1968; Threlfall & Whistance, 1970). We now report on the incorporation into ubiquinone by maize, *E. gracilis*, *P. blakesleeanus* and baker's yeast of cinnamic acid and *p*-coumaric acid, compounds known to give rise to *p*-hydroxybenzoic acid in higher plants (Zenk, 1966) and some fungi (Yoshida, 1969).

Maize shoots (200), *E. gracilis* cells (20g wet wt.), baker's yeast cells (100g wet wt.) and *P. blakesleeanus* mycelia (35g wet wt.) were incubated for 18h (maize) or 6h (*E. gracilis*, baker's yeast and *P. blakesleeanus*) under our standard conditions (Whistance *et al.* 1967; Spiller *et al.* 1968; Threlfall & Whistance, 1970) with either 4 μ Ci of [U - 14 C]cinnamic acid (10mCi/mmol) or 4 μ Ci of *p*-[U - 14 C]coumaric acid (12.9mCi/mmol) [prepared by incubating L-[U - 14 C]phenylalanine and L-[U - 14 C]tyrosine respectively with phenylalanine ammonia-lyase from *Rhodotorula glutinis* 1FO 559 (Ogata, Uchiyama, Yamada & Tochikura, 1967)]. At the end of the incubations the ubiquinones were isolated from the organisms and assayed for radioactivity (Whistance *et al.* 1967; Spiller *et al.* 1968; Threlfall & Whistance, 1970).

In all cases radioactivity was incorporated into ubiquinone, the major radioactive compound observed in the lipid fractions. The incorporation (percentage of dose) from [U - 14 C]cinnamic acid varied from 0.008 in maize to 0.0005 in baker's yeast; that from *p*-[U - 14 C]coumaric acid varied from 0.11 in baker's yeast to 0.03 in maize. The specific radioactivities (c.p.m./ μ mol) of the samples

labelled from [U - 14 C]cinnamic acid were 1860, 1228, 293 and 12 for maize, *E. gracilis*, *P. blakesleeanus* and baker's yeast respectively; those of the samples labelled from *p*-[U - 14 C]coumaric acid were 4450, 5310, 2630 and 800 respectively. Ozonolytic degradations and comparison of the specific radioactivities of the ubiquinone samples with those of the 4-demethylsterols established that greater than 90% of the radioactivity in the ubiquinone molecules was in the *p*-benzoquinone ring.

The results show that in all organisms examined the *p*-hydroxybenzoic acid utilized for ubiquinone biosynthesis can be formed from *p*-coumaric acid and, with the possible exception of yeast, cinnamic acid. However, they do not rule out the possibility that some of this *p*-hydroxybenzoic acid is also formed directly from chorismic acid.

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Oxidation of Furan-2-Carboxylate to 2-Oxoglutarate by *Pseudomonas putida* F2: Studies of Enzymology and Electron Transport

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Pseudomonas putida F2 grown with furan-2-carboxylate oxidizes this compound to 2-oxoglutarate through the following sequence of intermediates: furan-2-carboxylate $\rightarrow$ 2-furoyl-CoA $\rightarrow$ 5-hydroxy-2-furoyl-CoA $\rightarrow$ 5-oxo- Δ^2 -dihydro-2-furoyl-CoA $\rightarrow$ 2-oxoglutaryl-CoA $\rightarrow$ 2-oxoglutarate. A key reaction of this sequence, the hydroxylation of 2-furoyl-CoA, draws its oxygen from water with the resultant obligatory requirement for an electron acceptor, which may be satisfied by Methylene Blue or the membrane fraction from furan-2-carboxylate-grown cells (Jones & Trudgill, 1967; Trudgill, 1969).

Descriptions of other hydroxylations that draw their oxygen from water are confined to nitrogen-containing hydrophilic ring structures (Dagley &