CONFIDENTIAL

# PROJECT ANALYSIS

## NEW PHOSPHATE ESTER PROJECT

PLASTICIZERS DIVISION
COMMERCIAL DEVELOPMENT DEPARTMENT
MONSANTO INDUSTRIAL CHEMICALS COMPANY

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PROJECT ANALYSIS

NEW PHOSPHATE ESTER PROJECT

OBJECTIVES

To provide a "written down" long-term plan for dealing with toxicological and environmental problems connected with the phosphate ester plasticizers. This plan involves:

a. Commercial Development evaluation of the viability of existing candidates as new-product alternatives to our existing cresylic acid containing esters (S-140 and TCP).

b. Continuing R&D work (Synthesis, Application, Process) necessary to make these candidates available for commercialization.

c. Coordination of Medical Department input relative to toxicity data on both new and existing products, including competitive products.

d. Appropriate interface with Environmental Protection Agency and other pertinent regulatory groups.

e. Transferral of appropriate information to our customers.

REASONS FOR PROJECT

Prompted by regulatory action (Department of Transportation) controlling the flame spread, the automotive industry has turned to phosphate ester plasticizers and phosphorus flame retardants. Questions concerning their toxicological and environmental safety have arisen. The Environmental Protection Agency (Office of Toxic Substances) has already placed aryl phosphate esters high on their priority list and have an active program underway. They have requested (and received) information from us from time-to-time during the past year.

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The Ford Motor Company has, on two occasions, alleged that Santicizer 140 (cresyl diphenyl phosphate) caused certain toxicological effects through skin absorption. Other phosphate ester customers (General Tire, Olin Corp., General Electric) have raised the toxicity issue.

Through the years, phosphate ester plasticizers (particularly the trialkyl- and alkyl aryl esters) have been considered relatively non-toxic. Santicizer 141 (2-ethylhexyl diphenyl phosphate) is indeed broadly regulated by the FDA for food packaging. Acute oral toxicity studies ($LD_{50}$) show these esters to be relatively non-toxic. However, a search through the literature reveals disastrous epidemiological effects of *ortho cresylic* phosphate esters on both humans and animals. Most of these data reveal neurotoxicity. Both TCP and S-140 cause demyelination (attack on nerve sheath) and inhibit cholinesterase activity. Our results have shown S-140 to absorb through the skin of rats and cause cholinesterase inhibition. Our data also show no difference between cresylic acids designated as *"low ortho"* or *"high ortho."* Santicizer 141, Santicizier 148 and triphenyl phosphate do not cause neurotoxicity according to our tests.

All of the phosphate esters in our product line are toxic to fish. Santicizer 148 appears to be the least active, followed by S-141. TCP, Santicizer 140 and Kronitex 100 are moderately to highly toxic to fish according to this test. This hazard could be modified by the biodegradation rates of these esters -- TCP and TPP are the most biodegradable. S-140 and S-141 are next. K-100 and S-148 are the least biodegradable.

PRODUCT OPPORTUNITY JUSTIFICATION FOR PROJECT

As long as these opposing pressures continue -- on the one hand, from the Department of Transportation toward flame retardance; and on the other hand, from the EPA to reduce environmental hazard -- a phosphate ester which shows a good performance property balance and also is a good toxicity risk would present an excellent opportunity for Monsanto. The magnitude of our phosphate ester opportunity is shown in Table No. 1.



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TABLE NO. 1

MONSANTO WORLDWIDE PHOSPHATE ESTER PLASTICIZER POTENTIAL MARKET*

| | 1975 | 1976 | 1977 | 1978 | 1979 |
|---|---|---|---|---|---|
| TCP | 0 | 0 | 0 | 0 | 0 |
| S-140 | 5 | 0 | 0 | 0 | 0 |
| TPPa FLAKE | 7 | 8 | 10 | 11 | 13 |
| TPPa - GE | 8 | 10 | 14 | 18 | 21 |
| NEW TRIARYL | 0 | 1 | 5 | 8 | 10 |
| S-141/S-148 | 26 | 34 | 43 | 49 | 56 |
| S-148 | | | | | |
| TOTAL | 46 | 53 | 72 | 86 | 100 |

* Projections assume:

1. Newport on stream 1975, fourth quarter.
2. Bridgeport expansion on stream 1977, first quarter.

NOTE: Optimistic forecast is stated for General Electric usage of TPPa. If this market is reduced some of the loss can be made up with the new triaryl phosphate.

STATUS OF PROJECT

Because of the neurotoxicity problem, we committed, in late 1973, to exit from our cresylic acid-containing phosphate esters. No tricresyl phosphate was manufactured or sold as a plasticizer in 1974. We plan to discontinue Santicizer 140 (as it exists today) at the end of 1975.

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Three potential replacement candidates have emerged from R&D and are presently being evaluated by Commercial Development. In the order of their availability (based on raw material availability), they are:

a. p-tertiary butylphenyl diphenyl phosphate.

b. mp (99) cresyl diphenyl phosphate (mp-99 is a new cresylic acid with "zero" ortho isomer levels projected to be available from Koppers during early 1976).

c. m-ethylphenyl diphenyl phosphate (m-ethylphenol potentially available from Cosden in ca. 2 years).

Our neurotoxicity data have shown both p-tert-butylphenyl diphenyl phosphate and m-ethylphenyl phosphate to be free of demyelination using a stringent test procedure. Similar data on the mp-cresyl diphenyl phosphate is planned. Of extreme significance is our finding that the major competitor for these products, Kronitex 100, isopropyl phenyl diphenyl phosphate (mixed isomers) is neurotoxic. We anticipate that the EPA will soon (if not already) learn of the neurotoxicity associated with K-100 and thereby, put any potential new product in an excellent competitive position.

Performance-wise, p-tert butylphenyl diphenyl phosphate is somewhat deficient in low temperature flexibility as compared to K-100 and S-140. Other properties of ptBPDPP are very good. M-ethylphenyl diphenyl phosphate is excellent in low temperature properties, but poses a "possible" compatibility and/or light stability problem. Both of these products are under field testing now. Although interest in p-tBPDPP exists at Ford and other areas, m-ethylphenyl diphenyl phosphate holds a great deal of interest at Western-Electric. The mp-cresylic diphenyl phosphate is presumed to be identical to our S-140 in performance.

All of these products will be more expensive than the conventional S-140. However, we predict that a neurotoxic-free liquid triaryl phosphate will command a premium.



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