T E C H N I C A L B U L L E T I N

BIPHENYL

(diphenyl, phenyl benzene)

TECHNICAL BULLETIN IC/FF-29

Monsanto

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WATER_PCB-00012310

BIPHENYL

(diphenyl, phenyl benzene)

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Monsanto Industrial Chemicals Co.
A Unit of Monsanto Company
800 N. Lindbergh Blvd., St. Louis, Mo. 63166

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Table of Contents

	Page
GENERAL APPLICATIONS	3
PROPERTIES	3
SOLUBILITIES	4
BIPHENYL AS A DYE CARRIER FOR POLYESTER FIBERS	5
Introduction	5
Qualities of a Good Carrier	5
Methods of Using Biphenyl	7
Emulsifiers	7
Recommended Biphenyl Concentrations	7
TOXICITY	7
SHIPPING	8

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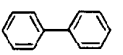
General Applications

Biphenyl is a thermally stable bicyclic compound produced by the thermal dehydrogenation of benzene. The following applications are known:

- Chemical intermediate — it can be alkylated, chlorinated, hydrogenated, nitrated and sulfonated.
- Low-pressure, high-temperature, non-corrosive heat-transfer medium.
- Wrapping paper impregnate to reduce citrus-fruit spoilage.
- Dye carrier for synthetic fibers.
- Manufacture of ceramics.
- Odor control.

Properties

Melting point, °C	69
Boiling point at 760 mm Hg, °C	255
10.5 mm Hg, °C	118
Specific gravity, 20°/4°C	1.04
77°/4°C	0.99
Lbs./gallon at 77°C	8.23
Refractive index, n_D^{77}	1.588
Viscosity at 70°C, Saybolt Sec.	31.2
100°C, Saybolt Sec.	28.8
Surface tension at 129.2°C, dynes/cm	39.5
Flash point, closed cup, °C	113
Open cup, °C	124
Latent heat of fusion, Btu/lb.	53.1
Specific heat, Btu/lb/°F	0.43
Odor	Pleasant, peculiar
Appearance	Colorless to pale yellow crystallized solid or flakes
Molecular Weight	154.20
Empirical Formula	$C_6H_5.C_6H_5$
Structural Formula	

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Solubilities — Grams biphenyl per 100 cc of solvent

	Solvents	*Solubility*	*°C.*
Hydrocarbons	Mineral Spirits	16.9	26
	Gasoline (Texaco)	24.1	26
	Kerosene	17.5	27
	Benzene	81.5	27
	Xylene	56.9	27
	Turpentine	24.2	24
	Toluene	62.0	18
Hydroxy Derivatives	Methyl Alcohol	7.45	24
	Ethyl Alcohol (3-A)	6.7	28
	n-Butyl Alcohol	9.1	27
	Amyl Alcohol	10.3	22
	Glycerine	Insol.	Rm. Temp.
	90% Phenol	17.8	28
Ethers	Ethyl Ether	57.8	24
	Cellosolve* Acetate	50.3	25
Ether Alcohols	Cellosolve	22.5	21
	Carbitol*	14.5	27
	Diethylene Glycol	Insol.	Rm. Temp.
Esters	Methyl Acetate	48.4	24
	Ethyl Acetate	56.6	22
	Butyl Acetate	73.4	29
	Amyl Acetate	55.4	27
	Ethyl Lactate	25.6	25
	Diethyl Phthalate	30.2	26
	Tricresyl Phosphate	50.0	34
Chloro Derivatives	Chloroform	110.0	19
	Carbon Tetrachloride	66.4	22
	Ethylene Dichloride	111.0	23
	Trichloroethylene	95.2	23
	Tetrachloroethane	106.2	22
	Monochlorobenzene	93.2	23
	Orthene	103.0	29
Ketone	Acetone	55.8	19
Aldehyde	40% Formaldehyde	Insol.	Rm. Temp.
Amines	Aniline	44.6	22
	Pyridine	40.0	25
Drying Oils	Tung Oil	36.2	34
	Linseed Oil	22.8	26
Acids	Acetic Acid	15.8	26
	Oletic Acid	20.2	25
Miscellaneous	Nitrobenzene	81.4	25
	Carbon Disulfide	149.6	26
	Distilled Water	Insol.	Rm. Temp.

*Trademarks of Union Carbide Corporation

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Introduction

The process of mercerizing depends largely on the ability of caustic soda to swell cellulose. But polyester fibers such as Dacron* and Terylene** present a more difficult problem. The polymers themselves are practically inert to most forms of chemical attack.

A few compounds have been found to have some swelling action. These swelling agents, or "carriers" as they are usually called, are organic chemicals that have the property of greatly increasing the rate of dyeing polyester fibers when added to the dye bath. By employing a carrier, full depths of shade may be obtained in normal dyeing times.

Qualities Of A Good Carrier

The efficiency of a carrier depends upon such factors as concentration required in the dye bath, temperature of dyeing, effect of variation in liquor-to-goods ratio, effect on the rate of dyeing and effect on the build-up of dyes. A successful carrier must have the following properties:

1. High efficiency
2. Availability at low cost
3. Little or no effect on the fastness properties of the dyed fiber
4. No smell or toxicity
5. No degradation or discoloration of the fiber
6. Ready removal after dyeing
7. Stability under dyeing conditions
8. Compatibility with the dyestuffs used

Monsanto's biphenyl meets the above qualifications for an effective and economical dye carrier.

High Efficiency

It has been shown that the dye bath exhaustion of 3% Dispersol Fast Scarlet B-150 powder fine can be increased from 48-80% at 100°C. and from 11-63% at 85°C. by the use of 8% emulsified biphenyl during a dyeing time of 60 minutes.

The use of biphenyl emulsifier also increases the leveling power of the applied dyestuffs. The leveling properties on Terylene fiber of disperse dyes applied with emulsified biphenyl are comparable with those of disperse dyes on nylon.

*Trademark of E. I. DuPont de Nemours & Co., Inc.
**Trademark of Canadian Industries Ltd. and Imperial Chemicals Industries, Ltd.

Availability At Low Cost

Biphenyl is the cheapest of the most popular dye carriers. (Ref. REVIEW OF THE DYEING OF POLYESTER FIBERS WITH DISPERSE DYES BY USING CARRIERS, Erich Frieser; Reyon, Zellwolle U. Chemiefasern 9, 378-83 (1959) C.A. *53*, 20810f, (1959).

In comparison with o-phenylphenol, biphenyl costs half as much for the production of the same color shades.

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Little Or No Effect On The Fastness Properties Of The Dyed Fiber

Any trace of biphenyl left on the fiber or the fabric has no detrimental effect on the properties of the fiber or its tight fastness.

Wet fastness properties show, in general, some improvement over corresponding dyeing with no carrier. The fastness to rubbing and dry cleaning of dyeings carried out with emulsified biphenyl are generally superior to those carried out without the use of a carrier.

No Smell or Toxicity

The slightly phenolic odor of biphenyl in fabric dyed using biphenyl as a dye carrier could be objectionable if a trace is left on the fiber. However, using the proper techniques, biphenyl residue should be completely removed. The normal procedure of vacuum drying the fiber or the fabric at 70-80°C. is sufficient. Additional information is discussed in the toxicity section.

No Degradation or Discoloration of the Fiber

Biphenyl has no detrimental effect on the color of the fiber and fabric, the fiber and fabric themselves or their blends.

Using biphenyl as a dye carrier, shrinkage is much less pronounced than with o- or p-phenylphenol.

Ready Removal After Dyeing

The normal procedure of vacuum drying the fiber or fabric at 70-80°C. is sufficient to remove the last traces of biphenyl. It is easier to remove biphenyl than o-phenylphenol using the vacuum oven drying method.

Stability Under Dyeing Conditions

Biphenyl is one of the most stable organic compounds — since it has no functional groups it does not enter into any chemical reaction with dyes used for polyester fibers or chemicals normally used in dyeing baths.

Compatibility With Dyestuffs

The effect of the carrier in the fiber does not depend directly on the type used but on the number of molecules present in the fiber. Thus, the more hydrophobic a substance is, the more suitable it will be as a carrier. Biphenyl is hydrophobic, contrary to o-phenylphenol.

Important qualifications for a good carrier are:

1. Insolubility in dye bath — biphenyl is extremely insoluble in water.
2. Solubility of dye in the carrier — biphenyl is an excellent solvent for many dyes.
3. Solubility of the fiber in the dye carrier. At high temperatures, biphenyl is an excellent solvent for fibers. Patent No. 2,710,849 describes a method for homogeneously dyeing aromatic polyesters using biphenyl as a solvent.

In the few instances where biphenyl yields unlevel dyeing, certain dyeing assistants increase leveling action by decreasing the rate of absorption. Sodium hydrocarbon sulfonates and nonionic surfactants both have this effect, particularly with blue disperse dyes.

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Methods Of Using Biphenyl

Water- and alkali-insoluble agents like biphenyl and mono- & dichlorobenzene are added to the dye bath as aqueous emulsions or dispersions; agents like benzoic acid and o-phenylphenol can also be used in this way, but it is more usual to predissolve them with sodium hydroxide (or to use the ready-made sodium salt) and liberate the free acid or phenol at the desired rate by gradually adding a weak acid during the dyeing process.

The main drawback to the liberation of the free dye carrier acids or o- and p-phenylphenol is the difficulty in maintaining the proper pH during the dyeing. It is well known that the performance of dyes in the dye bath is sensitive to the pH of the liquors. A slight change in the pH could effect the reproduction of correct shades.

Emulsifiers

The most recommended emulsifiers for biphenyl or hydrophobic carriers are the nonionic types (condensation products of alkylphenols with ethylene oxide). However, a small amount of anionic emulsifier such as sodium salts of naphthalene sulfonic acid, formaldehyde condensation products, sodium lignin sulfonate and sulfonated turkey oil and other alkylaryl sulfonates should be present to maintain an excellent level dyeing.

Recommended Biphenyl Concentrations

The concentration of biphenyl in the dye bath depends on the shade of the fiber or fabric required to achieve. Concentrations of approximately 4-12% of the weight of the fiber or fabric are recommended, as its action is comparatively insensitive to the liquor-to-goods ratio employed.

Because biphenyl may have the tendency to condense on the cooler parts of the equipment and drop back into the dye liquors where it could cause spots on the fabric, it is recommended that these sections be preheated to avoid any condensation.

Toxicity

Biphenyl is classed as slightly toxic by ingestion. Acute oral rat LD_{50} is reported from 2180 to 5040 mg/kg.

Biphenyl, when in contact with intact animal skin shows little irritation, but by prolonged contact it could be absorbed. Molten biphenyl will produce thermal burns.

Eye irritation appears to be mechanical in nature. However, splashes of molten biphenyl will produce thermal burns.

Inhalation is not a serious hazard due to the low vapor pressure at room temperature. However, if dustiness is too great, a dust respirator should be worn. Exposure to the concentrated vapors from the molten product requires a respirator with an organic cartridge.

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Treatment

If an excessive amount of biphenyl is ingested, induce vomiting and treat symptomatically.

Skin contact should be avoided. Wash off with soap and water. In case contact is made with molten material, treat as thermal burn.

In case of eye contact, flush out with water for at least 15 minutes. If contact is by molten material, treat as thermal burn.

Shipping

Shipping classification (U.S.):	Diphenyl (phenyl benzene)
Labeling:	Product label
Standard containers:	50 lb. net multiwall bags 260 lb. net fibre drums Tank trucks Tank cars

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2-3311-0772-6 Litho in U.S.A.

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CUSTOMER SERVICE CENTERS

AKRON, OHIO 44313
260 Springside Drive
Montrose Development Park
Tel. (216) 666-4111

ATLANTA, GEORGIA 30339
320 Interstate North Parkway
Suite 500
Tel. (404) 432-7111

BOSTON, MASSACHUSETTS 02149
Everett Station
Tel. (617) 387-5010

CHICAGO, ILLINOIS
3158 Des Plaines Ave.
Des Plaines, Illinois 60018
Tel. (312) 296-6688

CINCINNATI, OHIO 45206
1501 Madison Road
Tel. (513) 751-6707

DETROIT, MICHIGAN
500 Northland Towers West
Southfield, Michigan 48075
Tel. (313) 357-0910

HOUSTON, TEXAS 77027
1301 Post Oak Tower
5051 Westheimer Road
Tel. (713) 621-9550

LOS ANGELES, CALIFORNIA 90022
6670 E. Flotilla St.
Tel. (213) 723-2492

NEW YORK, NEW YORK 10036
1114 Avenue of the Americas
Tel. (212) 764-5000

ST. LOUIS, MISSOURI 63166
800 N. Lindbergh Blvd.
Tel. (314) 694-1000

SAN FRANCISCO BAY AREA
2710 Lafayette
Santa Clara, California 95052
Tel. (408) 243-0414

SEATTLE, WASHINGTON 98121
2112 Third Avenue
Tel. (206) 622-4203

WILMINGTON, DELAWARE 19810
Suite 204, Bancroft Bldg.
3411 Silverside Road
Tel. (302) 478-4600

Monsanto Industrial Chemicals Co.
A Unit of Monsanto Company
800 N. Lindbergh Blvd., St. Louis, Mo. 63166

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