Prior Filed Applications

The Office indicated that the filing dates of pending U.S. trademark applications for the marks SOLARYS (Serial No. 84/954,037, hereinafter the '037 application) and SOLARES (Serial No. 79/265,450 which has now registered as Registration No. 6,109,960, hereinafter the '960 mark) precede Applicant's filing date for the present SOLARIS trademark application and therefore may pose a bar to registration under Trademark Act Section 2(d) due to a likelihood of confusion. Applicant respectfully submits that there is no likelihood of confusion, and provides the following arguments and evidence for the Examiner's consideration.

The Applicant in the present application is a well-known, publicly traded medical device company committed to providing high-quality restorative products designed to accelerate achieving optimal health. Applicant designs, manufactures, and sells a broad range of products for clinical use in physical therapy, rehabilitation, pain management, and athletic training. Through its distribution channels, Applicant markets and sells its products to orthopedists, physical therapists, chiropractors, athletic trainers, sports medicine practitioners, clinics, hospitals, and consumers (see http://www.dynatronics.com). Applicant's products are marketed by Dynatronics Corporation and its divisions Bird & Cronin and Hausmann Industries under a portfolio of well-known family of marks which are recognized in the industry (see Exhibit A). Of particular relevance to the present matter, Applicant draws the Examiner's attention to the fact that Applicant has been marketing and selling its products under the related brand DYNATRON SOLARIS® (Reg. No. 2,957,937) since at least as early as 2003 (see Exhibit B). Accordingly, Applicant asserts that its brands as a whole, and particularly the related DYNATRON SOLARIS brand, are well-known in the industry.

With respect to the present application, the description of goods for the SOLARIS trademark (as amended in the present action) is as follows:

- IC 005. Analgesic preparations; Medical adhesive tape; Dietary and nutritional supplements
- IC 010. Physical rehabilitation, physical therapy and sports medicine equipment all designed specifically for medical use, namely, manually operated exercise equipment for physical therapy purposes, shoulder stretchers using a cable, manually-operated resistance bands and cables cable tubing for sports medicine physical therapeutic purposes, body rehabilitation apparatuses for medical purposes, force and motion testing apparatuses for physical rehabilitation, vibrating apparatuses used to stimulate muscles and increase strength and physical performance for health and medical purposes, whirlpools for therapeutic use, foam rollers for use in physical therapy, foam positioning pads for medical and physical therapy use, hand and finger exercisers for therapeutic purposes, splints for medical purposes, support bandages, air pillows and cushions for medical purposes, and orthopedic cushions and padding, all the foregoing capable of use in both home and clinical settings; manually-operated exercise equipment for physical therapy and sports medicine physical therapy purposes; Chiropractic instruments; Medical devices for physical therapy and sports medicine purposes, namely, heart rate monitors, health monitoring devices consisting of blood pressure monitors, thermometers, and pedometers, and body fat monitors; Medical diagnostic and therapy devices, namely, electro-therapy devices in the nature of static electric therapy apparatuses, massage instruments for soft tissue work, medical ultrasound apparatus devices for use in deep-heat tissue therapy, low frequency electric therapy apparatuses, and electronic light therapy apparatuses for the skin; Strength analysis devices in the nature of dynamometers for diagnostic muscle strength testing and force and motion testing apparatuses for physical rehabilitation; Medical ultrasound apparatuses, spirometry devices in the nature of spirometers, and laser devices in the nature of lasers for medical use and laser therapy stimulators for pain management for medical use; Laser biostimulation instruments for health care use in the nature of electronic light therapy apparatuses for the skin, electrotherapy stimulation apparatuses comprising electrical nerve and muscle stimulators, medical electrodes, transmitting pads for use with human and veterinary patients, namely, horses and dogs, all for providing electrotherapy via transcutaneous electrical nerve stimulation, and for providing electronic stimulation to muscles for physical therapy purposes; Patient examination and/or treatment tables; Chemically activated hot gel packs and non-medicated compresses for medical use; Therapeutic, chemically activated hot and cold therapy packs and compresses; Medical gowns; Back supports for medical purposes; Orthopedic support bandages, namely, wearable pads for the hands; Traction apparatuses for medical purposes; Walking aids for medical purposes; Whirlpools for use in hospitals or for therapeutic use
- IC 016. Anatomical models for scientific, instructional, and educational purposes
- IC 020. Massage tables
- IC 027. Personal exercise mats; Yoga mats
- IC 028. Exercising equipment, namely, pulleys; Exercise benches; Exercise weights; Parallel bars; Yoga straps

With respect to the ‘037 application for SOLARYS, the description of goods is limited to International Class 10, namely: “Aerosol delivery medical devices, namely, nebulizers used to atomize a liquid”. Applicant notes that nebulizers are medical devices designed to work with a compressed air source to convert liquid medication into an aerosol to be inhaled by the lungs. Nebulizers are used as a treatment option for asthma, cystic fibrosis, chronic obstructive pulmonary disease, and respiratory diseases and disorders (see Exhibit C). Nebulizers can be purchased over the counter at retailers such as CVS, Walgreens, or Walmart. Accordingly, the target consumer for the ‘037 application is well-defined and focused on a specific need within a limited channel of trade. Conversely, Applicant does not sell nebulizers nor any other breathing device. Additionally, Applicant does not sell goods through the listed retailers (CVS, Walgreens, or Walmart). Instead, Applicant’s goods are sold through Applicant’s website as well as through a network of authorized representatives. Thus, Applicant’s target consumer is well-defined and focused on a specific need in the categories of physical therapy, rehabilitation, pain management, and athletic training. Accordingly, the typical consumer of the goods associated with the ‘037 mark would not encounter the goods associated with the present application, or vice versa. As a result, Applicant asserts that there is no likelihood of confusion.

With respect to the ‘960 mark for SOLARES, the description of goods associated with the mark is as follows:

- IC 001. Chemicals used in industry, science and photography, agriculture, horticulture and forestry, except fungicides, herbicides, insecticides and parasiticides; chemicals for use in petrochemical, plastics, polyester and polystyrene goods industries; petrochemical products, namely, polypropylene resins, polyethylene resins, polystyrene resins; unprocessed polyethylene resins; styrene monomers; ethylene glycol; unprocessed polypropylene resins; paraxylene; unprocessed polystyrene and polystyrene resins; chemicals used in the manufacture of plastics and polystyrene; unprocessed plastics; paraxylene and goods made from these materials included in this class, namely, Terephthalic Acid (TPA), Purified Terephthalic Acid (PTA) and Dimethyl-Terephthalate (DMT)

- IC 016. Printed matter, namely, books, manuals, educational materials, reports, guides, brochures, booklets and newsletters in the field of petrochemicals, plastics, polyester, polystyrene; bookbinding material; photographs; stationery; adhesives for stationery or household purpose; paint brushes; typewriters; printed instructional and teaching material, except apparatus, in the field of petrochemicals, plastics, polyester, polystyrene; plastic materials for packaging, namely, plastic film for packaging; printers' type; printing blocks
- IC 017. Plastics in extruded form for use in manufacture; packaging, stopping and insulating materials in the nature of expanded plastic pellets; flexible pipes, not metal; semi-worked plastic substances, namely, semi-worked plastic sheets

Applicant notes that the goods associated with the '960 mark are chemicals and plastic components typically used in manufacturing, as well as associated printed marketing and packaging materials. In particular, Applicant notes that Terephthalic Acid (TPA) and Purified Terephthalic Acid (PTA) are organic compounds used primarily to make clothing and plastic bottles (see Exhibit D), and Dimethyl-Terephthalate (DMT) is an organic compound used primarily in the production of polyesters (See Exhibit E). Quite clearly, the target consumer for the '960 mark is well-defined and focused on a specific need within a limited channel of trade. Conversely, while any individual material may be a singular component in the manufacture of Applicant's goods, Applicant's target consumer and channel of trade are entirely different. Again, the typical consumer of the goods associated with the '960 mark would not encounter the goods associated with the present application, or vice versa. As a result, Applicant asserts that there is no likelihood of confusion.

Applicant respectfully reminds the Examiner that the likelihood of confusion standard requires probable confusion; a mere possibility is not sufficient (Rodeo Collection Ltd. v. West Seventh, 812 F.2d 1215 (9th Cir. 1987)). "The crucial issue is whether there exists a likelihood that an appreciable number of ordinary prudent purchasers will be misled, or simply confused, as to the source of the goods in question" (Lever Brothers Co. v. American Bakeries Co., 693 F.2d 251, 253 (2d Cir. 1983) wherein AUTUMN for margarine was determined not likely to be confused with AUTUMN GRAIN for bread). Where only a possibility, rather than a probability

of confusion exists, registration of an applicant's mark, even though similar to a registered mark, should be allowed (J. Thomas McCarthy, 3 McCarthy on Trademarks and Unfair Competition § 23:3 (4th ed. 1999).

For at least the reasons provided herein, Applicant respectfully submits that there is no likelihood of confusion between Applicant's mark and the prior filed applications, and respectfully requests that the present application be allowed.

EXHIBIT A

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Current Search: S1: **(live)[LD] AND (dynatronics)[OW]** docs: 12 occ: 27

	Serial Number	Reg. Number	Word Mark	Check Status	Live/Dead
1	88682310		SOLARIS	TSDR	LIVE
2	88067958	5824653	SEBAKMT	TSDR	LIVE
3	87601607	5598579	DYNATRONICS	TSDR	LIVE
4	78194776	2957937	DYNATRON SOLARIS	TSDR	LIVE
5	76146235	2671053	NUTURA	TSDR	LIVE
6	75501634	2409154	SYNERGIE	TSDR	LIVE
7	75351310	2362682	BODY ICE	TSDR	LIVE
8	75327886	2358040	DYNAHEAT	TSDR	LIVE
9	74800483	1796922	DYNATRON	TSDR	LIVE
10	73704205	1574609	DYNATRON	TSDR	LIVE
11	73419741	1280629	DYNATRON	TSDR	LIVE
12	73624035	1503579	SEBA DYNATRONIC	TSDR	LIVE

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Current Search: S3: **(live)[LD] AND (bird & cronin)[OW]** docs: 17 occ: 85

	Serial Number	Reg. Number	Word Mark	Check Status	Live/Dead
1	86238937	4662472	BIRD & CRONIN	TSDR	LIVE
2	86578565	4818045	PHYSICIAN'S CHOICE	TSDR	LIVE
3	86521487	4808002	VERSA-SLING	TSDR	LIVE
4	78283793	2945196	PHYSICIAN'S CHOICE	TSDR	LIVE
5	77513480	3575653	CINDY	TSDR	LIVE
6	77512321	3575617	CATH-MATE	TSDR	LIVE
7	77512637	3575622	TRACH-MATE	TSDR	LIVE
8	77417478	3723101	TRIO	TSDR	LIVE
9	77417237	3599874	L'TIMATE	TSDR	LIVE
10	77417875	3599877	B-COOL	TSDR	LIVE
11	76561634	2906041	F8	TSDR	LIVE
12	75692308	2448285	SPRINT	TSDR	LIVE
13	74585749	2010769	ANKLIZER	TSDR	LIVE
14	74585739	2010768	GENU-RANGER	TSDR	LIVE
15	74315740	1836233	SPIFFYS	TSDR	LIVE
16	74172733	1898757	CRADLES	TSDR	LIVE
17	73440893	1302742	COMFOR-TREDS	TSDR	LIVE

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Current Search: S5: **("Hausmann Enterprises")[OW]** docs: 2 occ: 2

	Serial Number	Reg. Number	Word Mark	Check Status	Live/Dead
1	73798383	1573161	H HAUSMANN	TSDR	LIVE
2	73713857	1509146	POWERMATIC	TSDR	LIVE

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EXHIBIT B

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Typed Drawing

Word Mark	**DYNATRON SOLARIS**
Goods and Services	IC 010. US 026 039 044. G & S: medical therapy devices, namely electrotherapy devices, ultrasound devices for use in deep-heat tissue therapy, and laser devices for use in pain related disorders. FIRST USE: 20030930. FIRST USE IN COMMERCE: 20030930
Mark Drawing Code	(1) TYPED DRAWING
Serial Number	78194776
Filing Date	December 16, 2002
Current Basis	1A
Original Filing Basis	1B
Published for Opposition	May 25, 2004
Registration Number	2957937
Registration Date	May 31, 2005
Owner	(REGISTRANT) Dynatronics Corporation CORPORATION UTAH 7030 Park Centre Drive Salt Lake City UTAH 84121
Attorney of Record	David B. Tingey
Prior Registrations	1280629;1574609;1796922
Type of Mark	TRADEMARK
Register	PRINCIPAL
Affidavit Text	SECT 15. SECT 8 (6-YR). SECTION 8(10-YR) 20150611.
Renewal	1ST RENEWAL 20150611
Live/Dead Indicator	LIVE

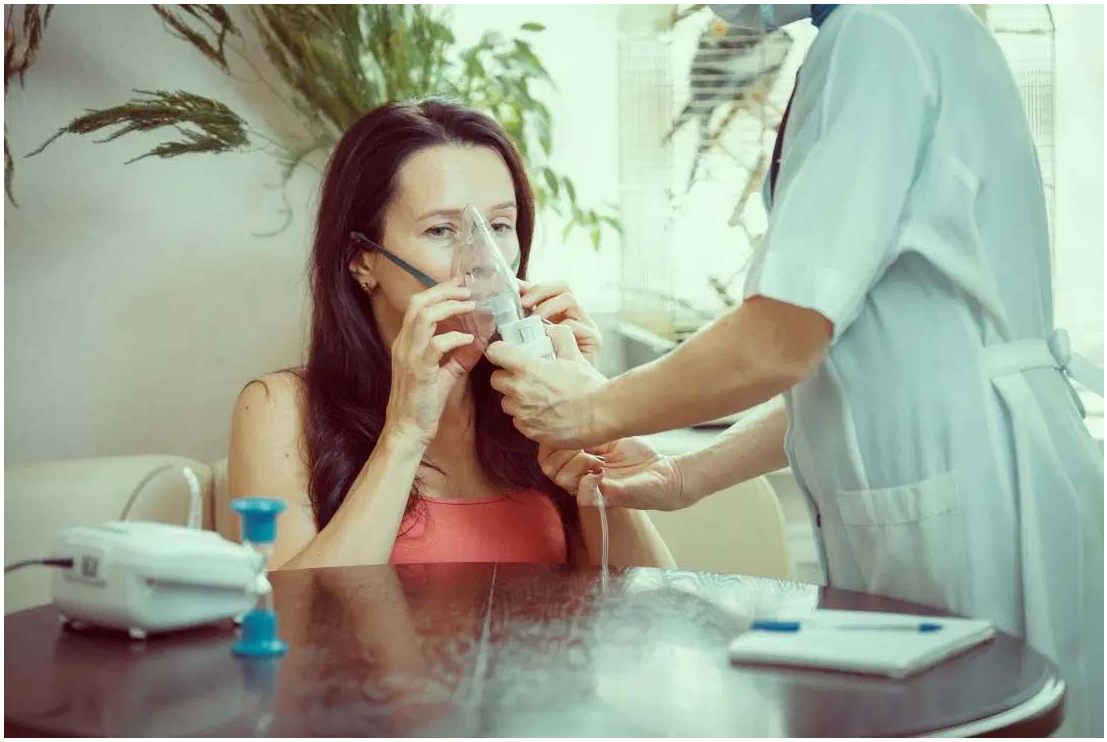
EXHIBIT C

Nebulizers: What they are and how to use them

Written by Nicole Galan, RN on April 12, 2019

A nebulizer is a piece of medical equipment that a person with asthma or another respiratory condition can use to administer medication directly and quickly to the lungs.

A nebulizer turns liquid medicine into a very fine mist that a person can inhale through a face mask or mouthpiece. Taking medicine this way allows it to go straight into the lungs and the respiratory system where it is needed.



A range of medical conditions may require a person to use a nebulizer.

Doctors typically prescribe nebulizers to people with one of the following lung disorders:

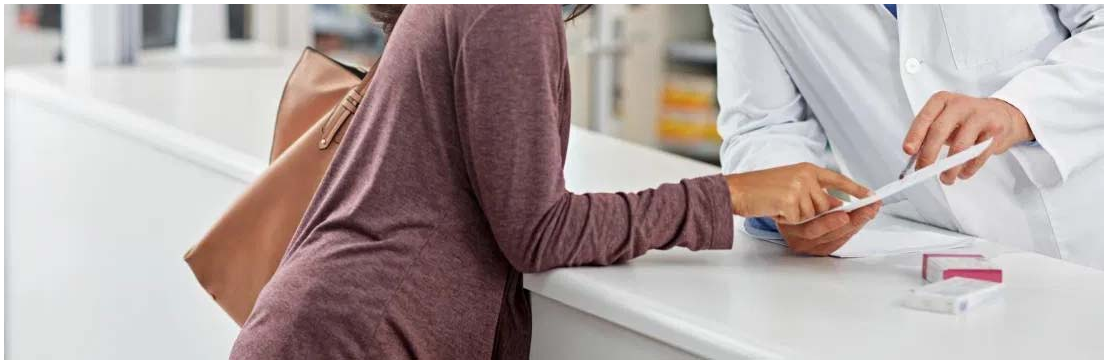
- asthma
- chronic obstructive pulmonary disease (COPD)
- cystic fibrosis
- bronchiectasis

Sometimes, a doctor will prescribe a nebulizer for a child who has a respiratory infection, such as bronchiolitis.

How to use a nebulizer

Before a person starts taking medicine with a nebulizer, a doctor or nurse will explain how the nebulizer works and answer any questions.

If a person receives their nebulizer from a pharmacy or medical equipment company, someone there will explain how to use it.



It is best to check with a pharmacist before purchasing a nebulizer machine.

Typically, a nebulizer and the medicine it uses require a prescription from a doctor or another healthcare provider.

It is possible to purchase a nebulizer machine online without a prescription, though a doctor will probably still need to prescribe the medication.

However, some medication manufacturers require the use of a specific type of nebulizer, so it is always a good idea to double-check with the pharmacist or doctor before making a purchase.

There are several types of medication that a person can use with a nebulizer:

- **Bronchodilators:** These are drugs that help open the airways and make breathing easier. Doctors often prescribe bronchodilators to people with asthma, COPD, or other respiratory disorders.
- **Sterile saline solution:** A nebulizer can deliver sterile saline to help open the airways and thin secretions. This may loosen and make it easier to cough up mucus in the lungs.
- **Antibiotics:** A nebulizer can deliver some types of antibiotics straight into the lungs or respiratory tract when someone has a severe respiratory infection.

Differences between nebulizers and inhalers

Nebulizers and inhalers have some similarities — for example, they both deliver medicine directly into the lungs to help make breathing easier. However, there are some important differences.

There are two types of inhalers: a metered-dose inhaler (MDI) and a dry-powder inhaler.

An MDI is the most common type of inhaler. Using one involves inhaling a premeasured amount of medicine through a mouthpiece. Some inhalers have a spacer, which makes it easier to inhale the medication.

A dry-powder inhaler is similar, but the medication is in powder form inside the inhaler. It requires the user to take a deep, fast breath, which pulls the powdered medicine deep into the lungs.

Both types require the ability to inhale the medicine deep within the lungs. Some children and people with severe respiratory diseases may

Nebulizers tend to be a little easier to use, in terms of delivering the medicine. However, a nebulizer may take up to 10 minutes to dispense the medication, and the user needs to sit still until they have inhaled all of it, which may be hard for a young child.

Also, nebulizers are not as portable; they can be difficult to carry around, while inhalers are typically smaller and more suitable for traveling.

How to maintain and clean the nebulizer

A person should refer to the instructions on how to maintain their nebulizer.

The nurse or pharmacist will demonstrate how to clean and maintain the device. The general guidelines are as follows:

- Wash the hands and work on a clean surface.
- Disconnect the tube, medicine chamber, mask, or mouthpiece, and wash them thoroughly in warm, soapy water.
- Allow the pieces to air dry on a clean towel.
- Disinfect the machine according to the manufacturer's instructions.

A person will need to replace some component pieces between three and four times per year. Consult the instruction manual to learn how and how often to do this. Also, make sure never to share pieces with another person.

It is essential to follow the instructions for cleaning, disinfecting, and replacement.

If a person does not take good care of a nebulizer, it can become contaminated by bacteria that can cause an infection. Infections can be very dangerous, particularly for a person with a lung disorder.

Summary

needed.

While the device is simple to operate, it is essential to use, clean, and maintain it correctly. Make sure to consult the manufacturer's manual, a pharmacist, or a healthcare provider with any questions or concerns.

0

Asthma Pulmonary System

+ 4 sources

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In general, a nebulizer is very easy to use, with only a few basic steps:

1. Wash the hands.
2. Add the medicine to the medicine cup, according to the doctor's prescription.
3. Assemble the top piece, tubing, mask, and mouthpiece.
4. Attach the tubing to the machine, according to the instructions.
5. Turn the nebulizer on; they can be battery- or electrically powered.
6. While using the nebulizer, hold the mouthpiece and medicine cup upright to help deliver all the medication.
7. Take slow, deep breaths through the mouthpiece and inhale all the medicine.

Please speak with the doctor or call the manufacturer with any questions or concerns about the device.

Is a prescription necessary?

EXHIBIT D

WIKIPEDIA

Terephthalic acid

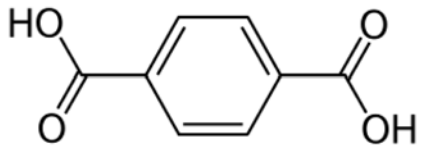
Terephthalic acid is an organic compound with formula $C_6H_4(CO_2H)_2$. This white solid is a commodity chemical, used principally as a precursor to the polyester PET, used to make clothing and plastic bottles. Several million tonnes are produced annually.[2] The common name is derived from the turpentine-producing tree *Pistacia terebinthus* and phthalic acid.

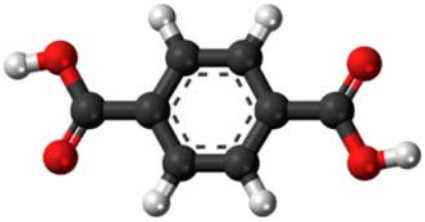
Contents

History

Terephthalic acid was first isolated (from turpentine) by the French chemist Amédée Cailliot (1805–1884) in 1846.[3] Terephthalic acid became industrially important after World War II. Terephthalic acid was produced by oxidation of *p*-xylene with dilute nitric acid. Air oxidation of *p*-xylene gives *p*-toluic acid, which resists further air-oxidation. Conversion of *p*-toluic acid to methyl p-toluate ($CH_3C_6H_4CO_2CH_3$) opens the way for further oxidation to monomethyl terephthalate, which is further esterified to dimethyl terephthalate. In 1955, Mid-Century Corporation and ICI announced the bromide-promoted oxidation of *p*-toluic acid to teraphthalic acid. This innovation

Terephthalic acid





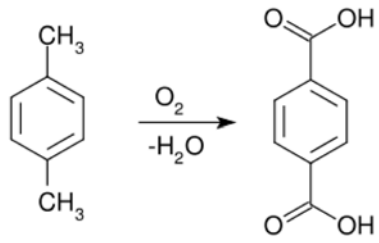
Names	
Preferred IUPAC name	Benzene-1,4-dicarboxylic acid
Other names	1,4-Benzenedioic acid Benzene-1,4-dioic acid Terephthalic acid *para*-Phthalic acid TPA PTA BDC
Identifiers	
CAS Number	100-21-0 (http://www.commonchemistry.org/ChemicalDetail.aspx?ref=100-21-0) ✓
3D model (JSmol)	Interactive image (https://chemapps.stolaf.edu/jmol/jmol.php?model=c1cc%28ccc1C%28%3DO%29O%29C%28%3DO%29O)
3DMet	B00943 (http://www.3dmet.dna.affrc.go.jp/cgi/show_data.php?acc=B00943)
Beilstein Reference	1909333

enabled the conversion of *p*-xylene to terephthalic acid without the need to isolate intermediates. Amoco (as Standard Oil of Indiana) purchased the Mid-Century/ICI technology.[4]

Synthesis

Amoco process

In the Amoco process, which is widely adopted worldwide, terephthalic acid is produced by catalytic oxidation of *p*-xylene:[4]



The process uses a cobalt–manganese–bromide catalyst. The bromide source can be sodium bromide, hydrogen bromide or tetrabromoethane. Bromine functions as a regenerative source of free radicals. Acetic acid is the solvent and compressed air serves as the oxidant. The combination of bromine and acetic acid is highly corrosive, requiring specialized reactors, such as those lined with titanium. A mixture of *p*-xylene, acetic acid, the catalyst system, and compressed air is fed to a reactor.

Mechanism

The oxidation of *p*-xylene proceed by a free radical process. Bromine radicals decompose cobalt and manganese hydroperoxides. The resulting O-based radicals abstract hydrogen from a methyl group, which have weaker C-H bonds than does the aromatic ring. Many intermediates have been isolated. *p*-xylene is converted to *p*-toluic acid, which is less reactive than the p-xylene owing to the influence of the electron-withdrawing carboxylic acid group. Incomplete oxidation produces 4-carboxybenzaldehyde (4-CBA), which is often a problematic impurity.[4][5] [6]

ChEBI	CHEBI:15702 (https://www.ebi.ac.uk/chebi/searchId.do?chebiId=15702) ✓
ChEMBL	ChEMBL1374420 (https://www.ebi.ac.uk/chembldb/index.php/compound/inspect/ChEMBL1374420)
ChemSpider	7208 (http://www.chemspider.com/Chemical-Structure.7208.html) ✓
ECHA InfoCard	100.002.573 (https://echa.europa.eu/substance-information/-/substanceinfo/100.002.573)
EC Number	202-830-0
Gmelin Reference	50561
KEGG	C06337 (https://www.kegg.jp/entry/C06337)
PubChem CID	7489 (https://pubchem.ncbi.nlm.nih.gov/compound/7489)
RTECS number	WZ0875000
UNII	6S7NKZ40BQ (https://fdasis.nlm.nih.gov/srs/srsdirect.jsp?regno=6S7NKZ40BQ) ✗
CompTox Dashboard (EPA)	DTXSID6026080 (https://comptox.epa.gov/dashboard/DTXSID6026080)
InChI	
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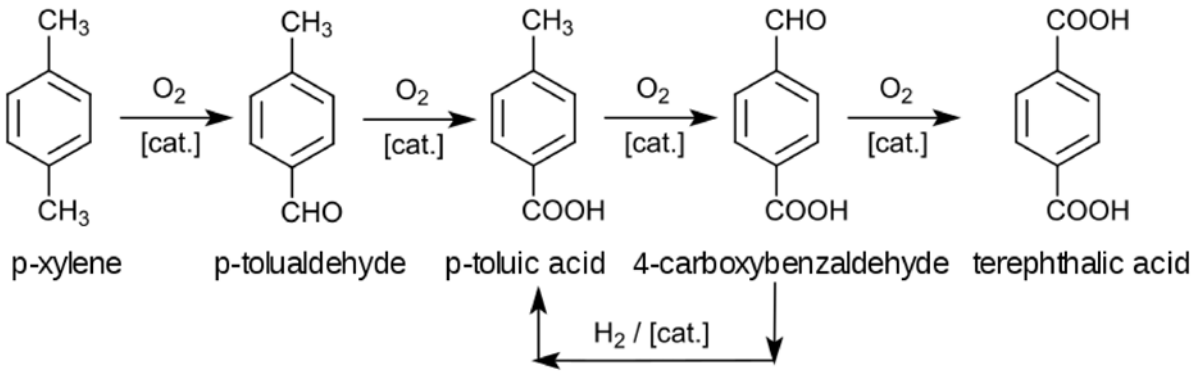
SMILES	

c1cc(ccc1C(=O)O)C(=O)O	
Properties	
Chemical formula	$C_8H_6O_4$
Molar mass	166.132 g·mol^{-1}
Appearance	White crystals or powder
Density	1.522 g/cm^3
Melting point	427 °C (801 °F; 700 K) in a sealed tube. Sublimes at standard atmospheric pressure.
Boiling point	Decomposes
Solubility in water	0.0015 g/100 mL at 20 °C
Solubility	polar organic solvents aqueous base
Acidity (pK_a)	3.51, 4.82[1]
Magnetic susceptibility (χ)	−83.51 × 10^{-6} cm^3/mol
Structure	
Dipole moment	0
Hazards	
Safety data sheet	*See: data page* MSDS sheet (http://physchem.ox.ac.uk/MSDS/TE/terephthalic_acid.html)
GHS pictograms	
GHS Signal word	**Warning**
GHS hazard statements	H315, H319, H335
GHS precautionary statements	P261, P264, P271, P280, P302+352, P304+340, P305+351+338, P312, P321, P332+313, P337+313, P362,

	P403+233, P405, P501
Related compounds	
Related carboxylic acids	Phthalic acid Isophthalic acid Benzoic acid *p*-Toluic acid
Related compounds	p-Xylene Polyethylene terephthalate Dimethyl terephthalate
Supplementary data page	
Structure and properties	Refractive index (*n*), Dielectric constant (ε_r), etc.
Thermodynamic data	Phase behaviour solid–liquid–gas
Spectral data	UV, IR, NMR, MS
Except where otherwise noted, data are given for materials in their standard state (at 25 °C [77 °F], 100 kPa). ✗ verify (what is ✓✗ ?) Infobox references	



Challenges

Approximately 5% of the acetic acid solvent is lost by decomposition or "burning". Product loss by decarboxylation to benzoic acid is common. The high temperature diminishes oxygen solubility in an already oxygen-starved system. Pure oxygen cannot be used in the traditional system due to hazards of flammable organic–O_2 mixtures. Atmospheric air can be used in its place, but once reacted needs to be purified of toxins and ozone depleters such as methylbromide before being released. Additionally, the corrosive nature of bromides at high temperatures requires the reaction be run in expensive titanium reactors.[7] [8]

Alternative reaction media

The use of carbon dioxide overcomes many of the problems with the original industrial process. Because CO_2 is a better flame inhibitor than N_2, a CO_2 environment allows for the use of pure oxygen directly, instead of air, with reduced flammability hazards. The solubility of molecular oxygen in solution is also enhanced in the CO_2 environment. Because more oxygen is available to the system, supercritical carbon dioxide (T_c = 31 °C) has more complete oxidation with fewer byproducts, lower carbon monoxide production, less decarboxylation and higher purity than the commercial process.[7][8]

In supercritical water medium, the oxidation can be effectively catalyzed by $MnBr_2$ with pure O_2 in a medium-high temperature. Use of supercritical water instead of acetic acid as a solvent diminishes environmental impact and offers a cost advantage. However, the scope of such reaction systems is limited by the even harsher conditions than the industrial process (300–400 °C, >200 bar).[9]

Promotors and additives

As with any large-scale process, many additives have been investigated for potential beneficial effects. Promising results have been reported with the following.[4]

- Ketones act as promoters for formation of the active cobalt(III) catalyst. In particular, ketones with a-methylene groups oxidize to hydroperoxides that are known to oxidize cobalt(II). Butanone is often used.
- Zirconium salts enhance the activity of Co-Mn-Br catalysts. Selectivity is also improved.[4]
- N-Hydroxyphthalimide is a potential replacement for bromide, which is highly corrosive. The phthalimide functions by formation of the oxyl radical.
- Guanidine inhibits the oxidation of the first methyl but enhances the usually slow oxidation of the toluic acid.

Alternative routes

Terephthalic acid can be prepared in the laboratory by oxidizing many *para*-disubstituted derivatives of benzene, including caraway oil or a mixture of cymene and cuminol with chromic acid.

Although not commercially significant is the so-called "Henkel process" or "Raecke process", named after the company and patent holder, respectively. This process involves the transfer of carboxylate groups. For example potassium benzoate disproportionates to potassium terephthalate and potassium phthalate rearranges to potassium terephthalate.[10][11]

Lummus (now a subsidiary of McDermott International) has reported a route from the dinitrile, which can be obtained by ammoxidation of *p*-xylene.

Applications

Virtually the entire world's supply of terephthalic acid and dimethyl terephthalate are consumed as precursors to polyethylene terephthalate (PET). World production in 1970 was around 1.75 million tonnes.[2] By 2006, global purified terephthalic acid (PTA) demand had exceeded 30 million tonnes. A smaller, but nevertheless significant, demand for terephthalic acid exists in the production of polybutylene terephthalate and several other engineering polymers.[12]

Other uses

- Polyester fibers based on PTA provide easy fabric care, both alone and in blends with natural and other synthetic fibers. Polyester films are used widely in audio and video recording tapes, data storage tapes, photographic films, labels and other sheet material requiring both dimensional stability and toughness.
- Terephthalic acid is used in paint as a carrier.
- Terephthalic acid is used as a raw material to make terephthalate plasticizers such as dioctyl terephthalate and dibutyl terephthalate.
- It is used in the pharmaceutical industry as a raw material for certain drugs.
- In addition to these end uses, Terephthalic acid based polyesters and polyamides are also used in hot melt adhesives.
- PTA is an important raw material for lower molecular weight saturated polyesters for powder and water-soluble coatings.
- In the research laboratory, terephthalic acid has been popularized as a component for the synthesis of metal-organic frameworks.
- The analgesic drug oxycodone occasionally comes as a terephthalate salt; however, the more usual salt of oxycodone is the hydrochloride. Pharmacologically, one milligram of *terephthalas oxycodonae* is equivalent to 1.13 mg of *hydrochloridum oxycodonae*.
- Terephthalic acid is used as a filler in some military smoke grenades, most notably the American M83 smoke grenade and M90 vehicle-employed smoke grenade, producing a thick white smoke that acts as an obscurant in the visual and near-infrared spectrum when burned.

Solubility

Terephthalic acid is poorly soluble in water and alcohols; consequently, until about 1970 terephthalic acid was purified as its dimethyl ester. It sublimes when heated.

Solubility (g/100 g solvent)

Solvent	25 °C	120 °C	160 °C	200 °C	240 °C
Methanol	0.1	—	2.9	15	—
Water	0.0019	0.08	0.38	1.7	9.0
Acetic acid	0.035	0.3	0.75	1.8	4.5
Formic acid	0.5	—	—	—	—
Sulfuric acid	2	—	—	—	—
Dimethyl formamide	6.7	—	—	—	—
Dimethyl sulfoxide	20	—	—	—	—

Vapor pressure

Temperature (°C)	Pressure (kPa)
303	1.3
353	13.3
370	26.7
387	53.3
404	101.3

Toxicity

Terephthalic acid and its dimethyl ester have very low toxicity, with LD_{50}s over 1 g/kg (oral, mouse).[2]

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7. Zuo, Xiaobin; Subramaniam, Bala; Busch, Daryle H. (2008). "Liquid-Phase Oxidation of Toluene and *p*-Toluic Acid under Mild Conditions: Synergistic Effects of Cobalt, Zirconium, Ketones, and Carbon Dioxide". *Industrial & Engineering Chemistry Research*. **47** (3): 546–552. doi:10.1021/ie070896h (https://doi.org/10.1021%2Fie070896h).
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11. Ogata, Yoshiro; Hojo, Masaru; Morikawa, Masanobu (1960). "Further Studies on the Preparation of Terephthalic Acid from Phthalic or Benzoic Acid". *Journal of Organic Chemistry*. **25** (12): 2082–2087. doi:10.1021/jo01082a003 (https://doi.org/10.1021%2Fjo01082a003).
12. *Ashford's Dictionary of Industrial Chemicals* (3rd ed.). 2011. p. 8805.

- *Encyclopædia Britannica* Eleventh Edition

External links and further reading

- Tedder, J. M.; Nechvatal, A.; Tubb, A. H., eds. (1975). *Basic Organic Chemistry: Part 5, Industrial Products* (https://archive.org/details/trent_0116401244110). Chichester, UK: John Wiley & Sons.

- International Chemical Safety Card 0330 (http://www.inchem.org/documents/icsc/icsc/eics0330.htm)

See also

- Polycyclohexylenedimethylene terephthalate a thermoplastic polyester formed from terephthalic acid

EXHIBIT E

WIKIPEDIA

Dimethyl terephthalate

Dimethyl terephthalate (DMT) is an organic compound with the formula $C_6H_4(COOCH_3)_2$. It is the diester formed from terephthalic acid and methanol. It is a white solid that melts to give a distillable colourless liquid.[1]

Contents

Production

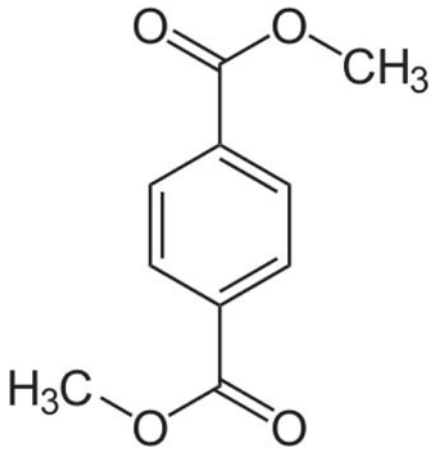
Dimethyl terephthalate (DMT) has been produced in a number of ways. Conventionally, and still of commercial value, is the direct esterification of terephthalic acid. Alternatively, it can be prepared by alternating oxidation and methyl-esterification steps from p-xylene via methyl *p*-toluate (PT).[1]

Dimethyl terephthalate (DMT) (Witten Process)

The common method for the production of DMT from *p*-xylene (PX) and methanol consists of a multistep process involving both oxidation and esterification. A mixture of p-xylene (PX) and methyl *p*-toluate is oxidized with air in the presence of a cobalt and manganese catalysts. The acid mixture resulting from the oxidation is esterified with methanol to produce a mixture of esters. The crude ester mixture is distilled to remove all the heavy boilers and residue produced; the lighter esters are recycled to the oxidation section. The raw DMT is then sent to the crystallization section to remove DMT isomers, residual acids and aromatic aldehydes.[2]

Oxidation of methyl p-toluate followed by esterification also yields dimethyl terephthalate (DMT) as shown in the below reaction:[1]

Dimethyl terephthalate



Names	
Preferred IUPAC name	Dimethyl benzene-1,4-dicarboxylate
Other names	Dimethyl terephthalate 1,4-Benzenedicarboxylic acid dimethyl ester Dimethyl 4-phthalate Dimethyl *p*-phthalate Di-Me terephthalate Methyl 4-carbomethoxybenzoate Methyl-p-(methoxycarbonyl)benzoate Methyl terephthalate Terephthalic acid methyl ester
Identifiers	
CAS Number	120-61-6 (http://www.commonchemistry.org/ChemicalDetail.aspx?ref=120-61-6) ✓
3D model (JSmol)	Interactive image (https://chemapps.stolaf.edu/jmol/jmol.php?model=COC%28%3DO%29C1%3DCC%

	3DC%28C%3DC1%29C%28%3DO%29OC) Interactive image (https://chemapps.stolaf.edu/jmol/jmol.php?model=O%3DC%28OC%29c1ccc%28cc1%29C%28%3DO%29OC)
Abbreviations	DMT
Beilstein Reference	1107185
ChemSpider	13863300 (http://www.chemspider.com/Chemical-Structure.13863300.html) ✓
ECHA InfoCard	100.004.011 (https://echa.europa.eu/substance-information/-/substanceinfo/100.004.011)
EC Number	204-411-8
MeSH	Dimethyl+4-phthalate (https://www.nlm.nih.gov/cgi/mesh/2014/MB_cgi?mode=&term=Dimethyl+4-phthalate)
PubChem CID	8441 (https://pubchem.ncbi.nlm.nih.gov/compound/8441) 12241382 (https://pubchem.ncbi.nlm.nih.gov/compound/12241382) ($^2H_4$)
RTECS number	WZ1225000
UNII	IKZ2470UNV (https://fdasis.nlm.nih.gov/srs/srsdirect.jsp?regno=IKZ2470UNV) ✓
CompTox	DTXSID0020498 (htt

Dashboard (EPA)	ps://comptox.epa.gov/dashboard/DTXSID0020498)

InChI
InChI=1S/C10H10O4/c1-13-9(11)7-3-5-8(6-4-7)10(12)14-2/h3-6H,1-2H3 ✓ Key: WOZVHXUHUFLZGK-UHFFFAOYSA-N ✓
InChI=1/C10H10O4/c1-13-9(11)7-3-5-8(6-4-7)10(12)14-2/h3-6H,1-2H3 Key: WOZVHXUHUFLZGK-UHFFFAOYSA-N

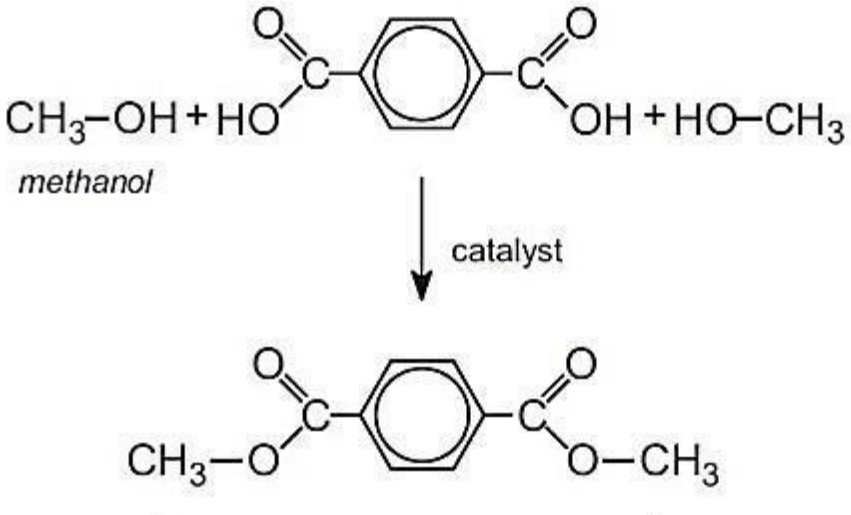
SMILES
COC(=O)C1=CC=C(C=C1)C(=O)OC
O=C(OC)c1ccc(cc1)C(=O)OC

Properties	
Chemical formula	$C_{10}H_{10}O_4$
Molar mass	194.186 g·mol^{-1}
Appearance	white solid
Density	1.2 g/cm^3, ?
Melting point	142 °C (288 °F; 415 K)
Boiling point	288 °C (550 °F; 561 K)
Acidity (pK_a)	-7.21
Basicity (pK_b)	-6.60

Except where otherwise noted, data are given for materials in their standard state (at 25 °C [77 °F], 100 kPa).

✓ verify (what is ✓✗ ?)

Infobox references

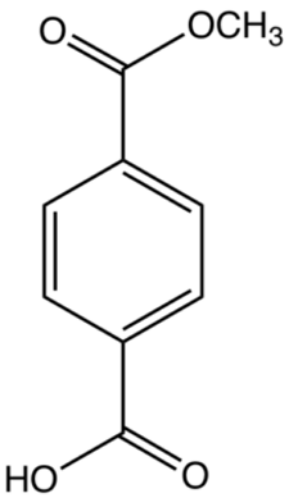


Dimethyl terephthalate (DMT) production through direct esterification

If highly impure terephthalic acid is available, DMT can be made in a separate process by esterification with methanol to dimethyl terephthalate, which is then purified by distillation:

$$C_8H_6O_4 + 2CH_3OH \rightarrow C_{10}H_{10}O_4 + 2\ H_2O$$

at presence of o-xylene at 250–300 °C.



Structure of monomethyl terephthalate.

Use

DMT is used in the production of polyesters, including polyethylene terephthalate (PET), polytrimethylene terephthalate (PTT), and polybutylene terephthalate (PBT). It consists of benzene substituted with carboxymethyl groups (CO_2CH_3) at the 1 and 4 positions. Because DMT is volatile, it is an intermediate in some schemes for the recycling of PET, e.g. from plastic bottles.

Hydrogenation of DMT affords the diol cyclohexanedimethanol, which is a useful monomer.

References

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2. "Dimethyl Terephthalate (DMT)" (http://www.gtctech.com/technology-licensing/polyester-technologies/dimethyl-terephthalate-technology/). 2013-05-02.

External links

- Supplier:Teijin Limited https://web.archive.org/web/20150503041344/http://www.teijin.com/products/chemicals/dmt/
- http://www.inchem.org/documents/icsc/icsc/eics0262.htm
- International Chemical Safety Card 0262 (https://www.ilo.org/dyn/icsc/showcard.display?p_lang=en&p_card_id=0262&p_version=2)
- U.S. National Library of Medicine: Hazardous Substances Databank – Dimethyl+terephthalate (http://toxnet.nlm.nih.gov/cgi-bin/sis/search/r?dbs+hsdb:@term+@na+@rel+Dimethyl+terephthalate)