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БЕЗПЕКА ЗАСТОСУВАННЯ ІЗОФТАЛЕВОЇ КИСЛОТИ ЯК КОМПОНЕНТА ПОЛІМЕРНИХ МАТЕРІАЛІВ

КУДРЯВЦЕВ А. В.[1], *аспір.,*
МІТІНА Н. Б.[2*], *канд. техн. наук, доц.,*
СИТАР В. І.[3], *канд. техн. наук, проф.*

[1] Кафедра інноваційної інженерії, Державний вищий навчальний заклад «Український державний хіміко-технологічний університет», вул. Набережна Перемоги, 40, 49094, Дніпро, Україна, тел. +38 (0562) 47-12-25, e-mail: bmw755ix@gmail.com, ORCID ID: 0000-0002-6299-2530
[2*] Кафедра безпеки життєдіяльності, Державний вищий навчальний заклад «Український державний хіміко-технологічний університет», вул. Набережна Перемоги, 40, 49094, Дніпро, Україна, тел. +38 (0562) 47-12-25, e-mail: natalimitina0000@gmail.com, ORCID ID: 0000-0002-5384-7040
[3] Кафедра інноваційної інженерії, Державний вищий навчальний заклад «Український державний хіміко-технологічний університет», вул. Набережна Перемоги, 40, 49094, Дніпро, Україна, тел. +38 (0562) 47-12-25, e-mail: v.sytar@ua.fm, ORCID ID: 0000-0003-0351-945X

Анотація. ***Постановка проблеми.*** Значне поширення полімерних матеріалів у різних галузях промисловості і сферах діяльності пояснюється термостійкістю полімерів, їх високими характеристиками міцності, тривалістю і надійністю експлуатації синтетичних матеріалів. Уведенням добавок можна змінювати фізико-механічні, теплофізичні, оптичні, електричні, фрикційні та інші експлуатаційні характеристики вихідного полімеру. ***Мета роботи*** – вивчення безпеки використання наповнювача ізофталевої кислоти у полімерній композиції. ***Методика.*** Застосування теоретичних методів дослідження, нормативних документів. ***Результати.*** Розглянуто сфери застосування полімерних матеріалів. Вивчено способи створення полімерів із заданими властивостями шляхом уведення в їх склад наповнювачів, в результаті чого змінюються не тільки експлуатаційні характеристики, а і фізико-хімічні ознаки вихідного полімеру. З урахуванням ідентифікації небезпеки застосування ізофталевої кислоти як наповнювача фенілону вивчено її фізико-хімічний склад, стабільність, реакційну здатність, токсичність, вплив на навколишнє середовище. Розглянуто заходи та засоби забезпечення пожежо- та вибухобезпеки, засоби контролю за небезпечним впливом, запобіжні заходи для персоналу та засоби індивідуального захисту під час роботи з ізофталевою кислотою. В результаті дослідження можливе отримання оптимальної полімерної композиції з поліпшеними пластичними характеристиками та безпечними властивостями. ***Наукова новизна***. Показано можливість одержання оптимальної полімерної композиції: з поліпшеними пластичними характеристиками за рахунок додавання до полімерного матеріалу фенілон біодеструктованого наповнювача ізофталевої кислоти; безпечними властивостями для людини та довкілля, а саме відсутність виділення токсичних речовин за впливу тепла, світла та інших зовнішніх дій. ***Практична значимість.*** Отриманий полікомпозиційний матеріал з оновленими пластичними характеристиками та властивостями безпеки можна застосовувати для подальшої переробки вторинної полімерної сировини.

Ключові слова: *безпека; біодеструктовані наповнювачі; ізофталева кислота; фенілон; полімерні композиційні матеріали*

SAFETY OF USING ISOPHTHALIC ACID AS A COMPONENT OF POLYMER MATERIALS

KUDRYAVTSEV A.V. [1], *Postgrad. Stud.,*
MITINA N.B.[2*], *Cand. Sc. (Tech.), Assoc. Prof.,*
SYTAR V.I. [3], *Cand. Sc. (Tech.), Prof.*

[1] Department of Innovative Engineering, SHEI "Ukrainian State University of Chemical Technology", 40, Naberezhna Peremohy Str., Dnipro, 49094, Ukraine, tel. +38 (0562) 47-12-25, e-mail: bmw755ix@gmail.com, ORCID ID: 0000-0002-6299-2530
[2*] Department of Life Safety, SHEI "Ukrainian State University of Chemical Technology", 40, Naberezhna Peremohy Str., Dnipro, 49094, Ukraine, tel. +38 (0562) 47-12-25, e-mail: natalimitina0000@gmail.com, ORCID ID: 0000-0002-5384-7040
[3] Department of Innovative Engineering, SHEI "Ukrainian State University of Chemical Technology", 40, Naberezhna Peremohy Str., Dnipro, 49094, Ukraine, tel. +38 (0562) 47-12-25, e-mail: v.sytar@ua.fm, ORCID ID: 0000-0003-0351-945X

Abstract. The widespread use of polymeric materials in various industries and fields of activity is explained by the thermal stability of polymers, their high strength characteristics, and the durability and reliability of synthetic materials. The introduction of additives can change the physical-mechanical, thermophysical, optical, electrical, frictional and other performance characteristics of the original (base) polymer. ***The purpose of the article*** is to investigate the safety of using isophthalic acid filler in a polymer composition. ***Methodology.*** Application of theoretical research methods, regulatory documents. ***Results.*** The spheres of polymeric materials application are considered. Ways of creating polymers with specified properties by introducing fillers into their composition, which change not only the operational characteristics, but also the physical and chemical characteristics of the original polymer are investigated. In view of the identification for danger of using isophthalic acid as a filler for phenylone, its physicochemical composition, stability, reactivity, toxicity, and environmental impact are studied. The measures and means of ensuring fire and explosion safety, means of controlling hazardous exposure, precautionary measures for personnel and personal protective equipment when working with isophthalic acid are considered. As a result of the research, it is possible to obtain an optimal polymer composition with improved plastic characteristics and safe properties. ***Scientific novelty***. The possibility of obtaining an optimal polymer composition is shown: with improved plastic characteristics due to the addition of the biodegradable isophthalic acid filler fenilon to the polymer material; safe properties for humans and the environment, namely the absence of toxic substances release under the influence of heat, light and other external actions. ***Practical value.*** The resulting polycomposite material with updated plastic characteristics and safety properties can be used for further processing of secondary polymer raw materials.

Keywords: *safety; biodegradable fillers; isophthalic acid; phenylone; polymer composite materials*

Introduction

Polymeric materials are widely used in various fields of human activity, from the domestic sphere and the food industry to heavy engineering, aviation, and space. Polymer composites are used in electrical engineering, machine tool building, tool industry, instrument making, tractor and agricultural engineering, in the transport sector, in agriculture, construction, light and food industries. But it is the machine-building industry that is the main consumer of almost all manufactured materials, including polymers. Currently, mechanical engineering is one of the world's leading industries and the use of polymeric materials in mechanical engineering is growing at an unprecedented pace in the history of mankind [12]. Thus, about 40 % of the plastic produced by the chemical industry is used in mechanical engineering. Various types of polymers are used for the manufacture of important parts of relatively small but structurally complex machines and mechanisms, and at the same time in the manufacture of large body parts of machines and mechanisms that carry heavy loads. Thus, about 50 % of rotating parts and gears are made of durable structural polymers, almost all functional parts of brake systems for cars and wagons and about 45 % for railway rolling stock are also made of synthetic press materials [1; 3].

The historical fact of the manufacture and practical use of a tram made entirely of plastic is known [1; 2]. Also, most modern small craft (boats, boats, etc.) are made of polymer materials.

The widespread use of polymeric materials in various industries and fields of activity is explained by the thermal stability of polymers, their high strength characteristics, and the durability and reliability of synthetic materials. And this is especially important when decorating the interiors of cars, ships, aircraft; when performing work in aggressive environments (for example, galvanic baths).

A positive fact is that the most advanced technologies and methods are used for the production of most polymers. And this increases the useful level of use of not only the actual polymeric materials, but also their waste, which increases the exchange rate of expensive materials. Along with this, the cost of living labor is significantly reduced. Thus, the simplest and most convincing example is the manufacture of printed circuits: a process that is inconceivable without polymer materials, and with them, fully automated [5].

Thus, the use of polymeric materials ensures the conservation of both material and energy resources, as well as the growth of labor productivity in the relevant industries.

Objective

The purpose of this work is to study the safety of using isophthalic acid as a filler in a polymer composition.

Materials and Methods research

To create polymeric materials with desired properties, base polymers are mixed with other substances − fillers [5].

Most modern polymeric materials are multicomponent systems in which various additives are present along with the polymer base. The content of filler additives in the polymer composition can vary within very wide limits. Depending on the task, the type of additive and the nature of the polymer, it can range from fractions of a percent to 95 % [2; 4].

The introduction of additives can change the physical-mechanical, thermophysical, optical, electrical, frictional and other performance characteristics of the original (base) polymer.

Therefore, it is possible to optimize the plastic properties of the phenylone polymer by adding isophthalic acid.

Solid fillers can be mineral, organic, ceramic and metal. In form, it can be fine powders and fibrous materials. The most widely used fine fillers of mineral origin: talc, chalk, kaolin, mica, asbestos, white soot, aerosil, metal oxides [4].

Results research and discussion

In this work, as an additive the use of a dispersed filler of organic origin − isophthalic acid.

Despite the scope of the polymer and the filler included in its composition, it is necessary to determine the safety and additives, and the resulting polymer composition.

Currently, in the development of polymeric materials, special attention is paid to three safety parameters that can potentially cause significant harm to human health and the environment:

− it is necessary to take into account the presence of impurities in polymeric materials that may be unsafe for human health;

− substances harmful to human health during the operation of various polymers under the influence of heat, light or other external phenomena;

− the formation of substances that can cause corrosion or other damage to technical products [6].

Potential toxicity polymers evaluated proceeding from from several parameters and eliminated the introduction of additives of plasticizers and modifiers that block odors and other volatile substances.

Toxicity polymers maybe to be rated requirements proceeding from from next parameters:

− polymers should not create smell;

− release into the air volatile substances (in hazardous concentrations);

− worsen microclimate premises (humidity);

− stimulate development microflora;

− create tension static electric field.

Among the most harmful substances can name carbamide epoxy and phenol formaldehyde resins that allocate significant amount harmful and dangerous substances into the air [6].

Next harmful substances consider styrene-containing rubber linoleums and nitrolenoleums, which are not recommended for use in residential premises.

Additives of plasticizers and modifiers locking odors and others volatile substances (they bind esters), allow you to get environmentally friendly materials [6; 7].

Subject to given information necessary estimate the safety of using isophthalic acid, proposed as a filler for the polymeric material phenylone.

Isophthalic acid (IR) − an organic substance, a dibasic dicarboxylic aromatic acid with a meta-arrangement of carboxyl groups. It is an isomer of phthalic and terephthalic acids. It is colorless crystals, almost odorless. Isophthalic acid is highly soluble in aqueous solutions of alkalis, but poorly in water, acetic acid and lower alcohols. Formula: substances − $C_8H_6O_4$. Molar mass – 166,14 g/mol. Density – 1,53 g/cm³ [8]. The structural formula has the form shown in Figure.

According to its chemical properties, isophthalic acid, being a typical carboxylic acid, forms salts and esters (isophthalates) at one or both carboxyl groups. When interacting with $SOCl_2$ or acetyl chloride, when heated, it turns into the corresponding acid chloride. The benzene ring in the isophthalic acid molecule is

capable of being reduced to cyclohexane under the action of hydrogen on platinum catalyst. Also, isophthalic acid enters into typical electrophilic substitution reactions: halogenated in fuming sulfuric acid to a tetrahalogen derivative, nitrated with concentrated nitric acid to form 4-and 5-nitro derivatives, sulfonated to 5-sulfoisophthalic acid [9; 10].

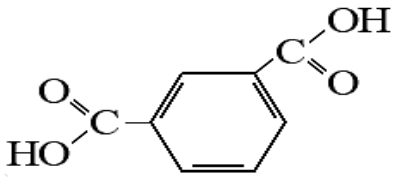

Fig. Structural formula and zophthalic acid

From the point of view of the safety of use, isophthalic acid belongs to the second hazard class, namely, to the group of substances with a general toxic effect [8]. May cause functional disorders of the central nervous system if inhaled. If the maximum allowable concentration (MAC) is exceeded, allergic diseases are possible. In large quantities, isophthalic acid irritates the mucous membranes of the skin and eyes. Therefore, recommended MPCs in the air have been determined, which are 0,2 mg/m³, LD 50 in rats − about 120 mg/kg [11; 12].

Based on the analysis of the information provided, generalizations were made regarding the safety of using isophthalic acid as a filler for the polymeric material phenylone for a number of indicators (Tables 1, 2).

Table 1

Fire o − and explosion hazard

Index	Special Hazards	Preventive measures	Fire extinguishing
Fire and explosion	Fuel. Fine particles form explosive mixtures in the air.	DO NOT use open flame. Closed system, explosion-proof (for dusty environments) electrical equipment and lighting. Avoid settling of dust.	Use water spray, foam, powder, carbon dioxide

Table 2

Dust generation

Avoid the formation of dust			
Symptoms		Preventive measures	First aid
Inhalation	Functional disorders of the central nervous system	Apply local extraction	Fresh air, peace
Skin	Irritates the mucous membrane	Protective gloves	Remove contaminated clothing. Rinse skin with plenty of water or take a shower
Eyes	Irritates the mucous membrane	Use eye protection	First of all, rinse with plenty of water for several minutes (remove contact lenses if possible without difficulty), then seek medical attention
Ingestion	Nausea	Do not eat, drink or smoke while working	Drink at least two glasses of water

For the personal safety of workers: eyes and faces, it is recommended to use open protective goggles with shields that have passed the test or EN 166 (EU); respiratory organs respirators with filter type P1; non-trile rubber gloves to protect the skin of the hands.

Additional information on the biological safety of isophthalic acid is as follows isophthalic acid was also not confirmed [13]. The product is chemically stable under standard environmental conditions. Germ cell mutagenicity testing was performed on hamster ovaries. A negative result has been obtained. Checking the metabolic activity of cells under the action of isophthalic acid was also not confirmed. There are no data on the carcinogenicity and reproductive activity of isophthalic acid, its specific selective activity in which individual target organs are affected. It has been established that isophthalic acid is a biodegradable substance under aerobic conditions by 85 % within 14 days.

Taking into account the available data on the properties of isophthalic acid, the main areas of its use are also considered: as an intermediate product in the production of unsaturated polyester and alkyd resins (mainly for surface coatings), paint, reinforced plastics, and packaging. Isophthalic acid is used as a comonomer in the production of polyethylene terephthalate bottle resins and some rubbers. It

provides excellent hardness, corrosion and stain resistance, hydrolytic and thermal stability and low resin levels. It is also used to make insulation materials, and polymerization with maleic anhydride and subsequent crosslinking with styrene results in high performance unsaturated polymers. Esters of isophthalic acid: dimethyl isophthalate, diethyl isophthalate, dioctyl isophthalate, diallyl isophthalate are important products of the chemical industry and are indispensable in the production of PVC plasticizers, they are characterized by a low degree of phytotoxicity. Derivatives of isophthalic acid are of limited use in the pharmaceutical industry.

Conclusion

The possibility of obtaining an optimal polymer composition with improved plastic characteristics by adding a biodegradable filler based on isophthalic acid to the phenylone polymer material is shown. The resulting polymer composition has safe properties for humans and the environment: no release of toxic substances under the influence of heat, light and other external influences.

Prospects further research

The need to obtain a polymer composition with optimal characteristics is also explained by the fact that polymer composite materials are one of the most important and widely used classes of modern structural materials. Their consumption is constantly growing and in developed countries is more than 100 kg per year per inhabitant. The polymeric material phenylone with updated plastic characteristics and relatively safe properties can be used for further processing of secondary raw materials.

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