APARATURA
BADAWCZA I DYDAKTYCZNA

System for waste management of acrylic adhesives

KRZYSZTOF ZYCH, ROBERT PEŁECH, MONIKA ŁĄGIEWCZYK, ZBIGNIEW CZECH
WEST POMERANIAN UNIVERSITY OF TECHNOLOGY SZCZECIN, INSTITUTE OF CHEMICAL ORGANIC TECHNOLOGY

ABSTRACT
The subject of this article is to present a system for disposal the waste acrylic pressure-sensitive adhesives (PSAs), which may occur in industry during production of acrylic adhesives. Poly(alkyl acrylates) play significant role in the industry, which was the impulse to elaborate useful method for recovering waste PSA and to find system, which could be applied in order to recover some of the monomers used in synthesis of PSA. The presented apparatus was tested in laboratory environment, however the results were enough satisfactory and promising that it could be utilize in a larger scale in the future.

Układ do zagospodarowania odpadów z klejów poliakrylanowych

STRESZCZENIE
Przedmiotem tego artykułu jest przedstawienie układu do zagospodarowania odpadowych samoprzylepnych klejów poliakrylanowych (PSA), które powstają w przemyśle podczas produkcji klejów poliakrylanowych. Poli(alkilo akrylany) odgrywają znaczącą rolę w wielu gałęziach przemysłu, co było bodźcem do opracowania użytecznej metody odzyskiwania odpadowych klejów oraz konstrukcji aparatury, która może być zastosowana do odzysku części monomerów użytych do ich syntezy. Przedstawiona aparatura została zbadana w warunkach laboratoryjnych, jednakże wyniki badań były na tyle satysfakcjonujące i obiecujące, że istnieje możliwość jej zastosowania w przyszłości w skali przemysłowej.

1. INTRODUCTION

Acrylic adhesives, especially acrylic pressure-sensitive adhesives (PSAs), are used mainly to produce many materials with self-adhesive properties in room temperature and higher temperatures. These materials are produced in form of double-, single-sided as well as carrier-free pressure-sensitive adhesive tapes (films) used to bond variety of materials with themselves. There are many other applications of acrylic adhesives such as: labels, adhesive tapes, sticking plasters, electrodes and bioelectrodes, hydrogels and wide gamut of adhesives products activated thermally. Acrylic adhesives exhibit very good thermal resistance in temperature range about 140-160°C. Prolonged heating of acrylic PSAs over 160-180°C leads to first signs of thermal degradation. Above 180°C they occur slow thermal decomposition, which undergo violent acceleration after exceeding 220-240°C. In temperatures above 440°C acrylic adhesives undergo pyrolysis very easily giving specific gaseous, liquid and solid products of thermal degradation [1].

The pyrolysis of polymers is used recently in utilization of waste and to recover precious organic raw materials. These substances, especially liquid products of thermal degradation of polymers, are separate using distillation and utilize again in processes of polymer technology and other organic technologies. The purpose of this article is to present system for waste management of polymer waste formed during production, coating or application acrylic adhesives. The system bases on utilizing controlled pyrolysis method, which is thermal degradation of waste acrylic adhesives in elevated temperatures in order to obtain and recover liquid products such as: primary alcohols, acrylates, methacrylates and olefins. The separation of these products is possible using distillation and freezing out light gaseous products. Recovered organic products can be successfully reprocessed in polymer technology.

2. METHOD

The method for disposal the waste acrylic adhesives consists in thermal decomposition in pyrolysis furnace and in the next stage separation of pyrolysis products. The pyrolysis of the adhesive is conducted in the furnace heated with electric current or in furnace heated with combustion gases of a temperature

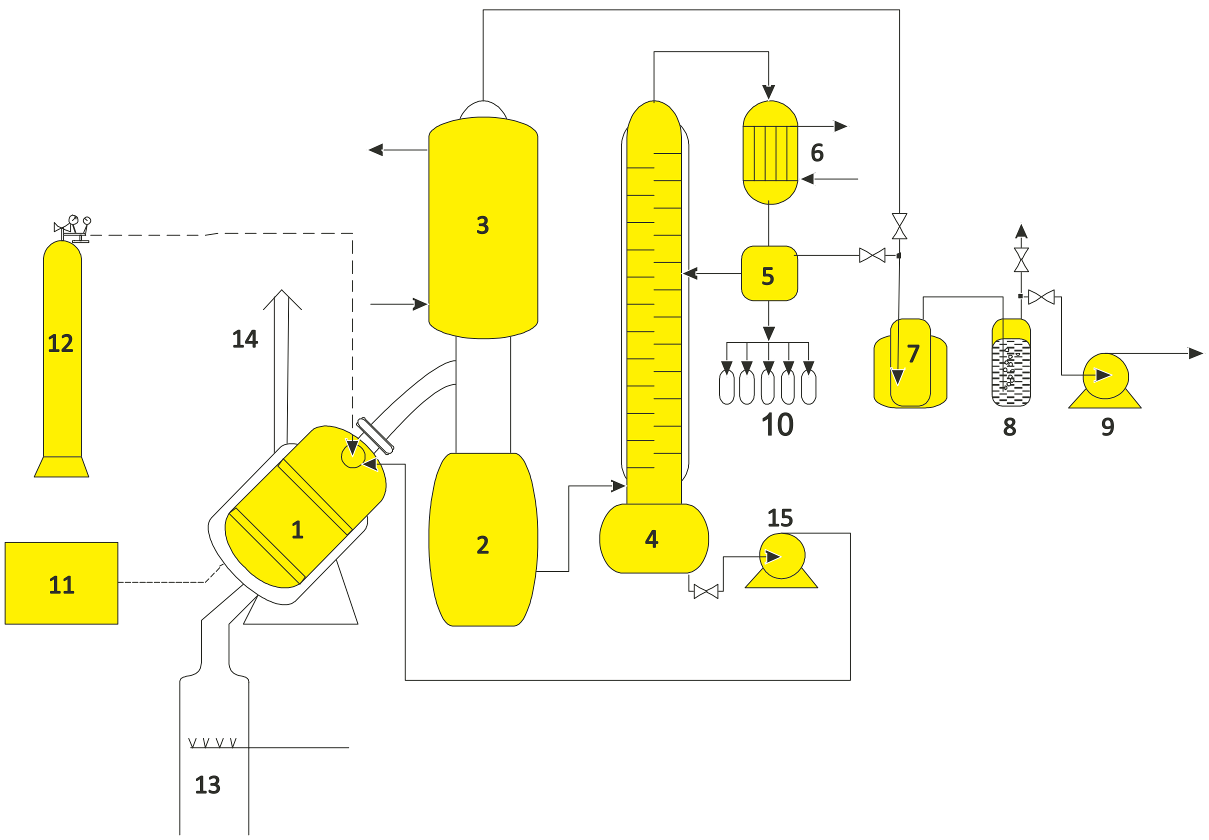

Figure 1. System for pyrolysis integrated fractionation of the products of the pyrolysis:
1 – pyrolysis furnace, 2 – liquid products tanker, 3 – condenser, 4 – liquid products distillation-rectiyfing column, 5 – reflux tanker, 6 – condenser, 7 – gaseous products cold trap, 8 – carbon dioxide absorber, 9 – vacuum pump, 10 – fraction collector, 11 – electrical heater feeder and temperature regulator, 12 – oxide cylinder, 13 – gaseous heater, 14 – exhaust gases outlet, 15 – distillation residue forcing through pump.

about 250-500°C [2]. For increase intensification of the process the solid and rotary furnace were applied.
The scheme of the system for pyrolysis integrated with fractionation of the products in solid furnace is shown in Figure 1.
The scheme of the system for pyrolysis integrated with fractionation of the products in rotary furnace is shown in Figure 2.
The pyrolysis process is conducted periodically. Collected waste of acrylic adhesives are placed in pyrolysis furnace 1. The pyrolysis furnace is heated using electric current feeded from regulator 11. To lower the price of the process heating with combustion gases, derived from combusting of natural gas or products of pyrolysis, could be used. The temperature of the combustion gases should be in range 450-650°C. After loading the furnace and starting heating the content of the furnace is heated to temperature 350-450°C. At this temperature the content of the furnace give in to pyrolytic decomposition. The acrylic adhesives give in to thermal degradation mainly in the course of main chain depolymerization and side chain thermal degradation in the course of alcohols forming the acrylate and olefins formed as a result of alcohols dehydration. The pyrolysis products in the form of gases are sent to condenser 3 and there are condensed. Liquefied pyrolizate is collected in tanker 2 placed under the condenser. In the case of pyrolysis adhesives based on acrylates of small molecular alcohols such as ethanol, butanol during pyrolysis gaseous products in form of olefins such as ethylene and butane are formed. These products, after passing through the condenser 3, are freezed out in a cold trap 7. A portion of olefins dissolve in higher boiling products of the pyrolysis. They can be removed directly from the condensate tanker 2 with stripping under diminished pressure with the use of vacuum pump 9. Carbon dioxide, which is formed during pyrolysis, is captured in the absorber placed before vacuum pump. As a absorber a packed column (for example with Raschig rings) is applied sprinkled with aqueous solution of NaOH or KOH with the concentration about 1-30%, depending on the adhesive, or scrubber filled with these solutions. After finishing the pyrolysis (no more drops of the condensate in condenser 3) the collected condensate is sent to distillation-rectifying column 4.

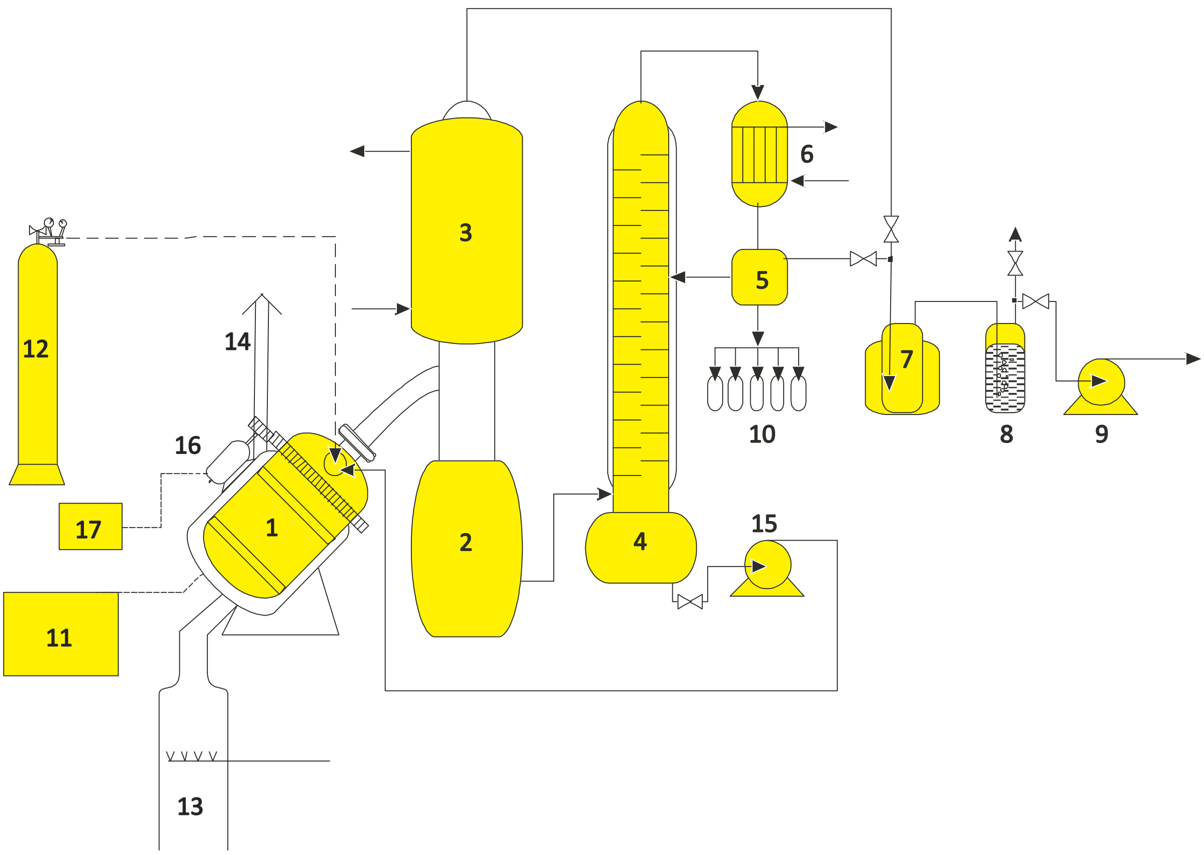

Figure 2. System for pyrolysis integrated fractionation of the products of the pyrolysis: 1 – pyrolysis furnace, 2 – liquid products tanker, 3 – condenser, 4 – liquid products distillation-rectifying column, 5 – reflux tanker, 6 – condenser, 7 – gaseous products cold trap, 8 – carbon dioxide absorber, 9 – vacuum pump, 10 – fraction collector, 11 – electrical heater feeder and temperature regulator, 12 – oxide cylinder, 13 – gaseous heater, 14 – exhaust gases outlet, 15 – distillation residue forcing through pump, 16 – motor, 17 – control and supply of the power feed

In this column the fractionation of the pyrolizate components is proceeding. The components of the pyrolizate are collected in the fraction collector 10. Additionally using the vacuum pump the residual light olefins are stripped and freezed out. Distillation residue in the form of dark viscous liquid consisted of mainly higher molecular products of the pyrolysis can be recirculated to pyrolysis furnace and use with the next furnace feed.

3. RESULTS

The acrylic pressure-sensitive adhesives used in the research were based on butyl acrylate with average weight molecular mass 500 000 D (example 1 and 3) and 250 000 D (example 2 and 4). The research was conducted in the system for pyrolysis integrated with fractionation of the products in solid furnace as well as in rotary furnace. The acrylic PSAs were loaded in the furnace. The temperature of the furnace was set to 450°C. The process was conducted in solid furnace (example 1 and 2) and rotary furnace (example 3 and 4). The results of the pyrolysis are presented in Table 1 and Table 2.

Table 1. The amounts of the pyrolysis products in solid furnace

Example	Furnace feed [g]	Condensate [g]	Residual [g]	Absorbed CO_2 [g]
1	160	140	14	3
2	160	142	9	3

Table 2. Conditions of the pyrolysis of acrylic PSAs

Example	Time needed to obtain temperature of the pyrolysis (400°C) [min]	Time of the pyrolysis [min]
1	15	90
2	15	90
3	8	60
4	9	60

After fractional distillation the products of the pyrolysis were analyzed using gas chromatography. After fractional distillation the amounts of the obtained products from solid furnace are as follows:
Example 1: 58 g butyl acrylate, 34 g butanol, 22 g butyl methacrylate, 12 g butane and 8 g of water.
Example 2: 31 g butyl acrylate, 79 g butanol, 12 g butyl methacrylate, 7 g butane and 8 g of water.
After fractional distillation the amounts of the obtained products from rotary furnace were similar as in the examples 1 and 2. After the pyrolysis the furnace was flushed with oxygen at 500°C to burn out the carbonizate, which could be used as a raw material in the production of active carbon.

4. CONCLUSIONS

The disposal of acrylic pressure-sensitive adhesives based on butyl acrylate using pyrolysis could be successfully conducted utilizing system for waste management presented in this paper. The liquid products of the pyrolysis give in to fractionation on distillation-rectifying column with good enough yields towards advisable products. With the use of rotary furnace the time needed to obtain the temperature of the pyrolysis (400°C) cut down from 15 minutes to about 10 minutes and the overall time of the pyrolysis from 90 minutes to 60 minutes. The results were satisfactory and promising enough, that the system for waste management of acrylic adhesives, can be utilize in a larger scale in the future.

LITERATURE

[1] Czech Z., Pełech R., Use of pyrolysis and gas chromatography for the determination of acrylic acid concentration in acrylic copolymers containing carboxylic groups, Polymer Testing, 27 (7), 870-872, 2008.

[2] Pełech R., Czech Z., Zych K., Sposób zagospodarowania odpadów z klejów poliakrylanowych oraz układ do zagospodarowania odpadów z klejów poliakrylanowych, zgłoszenie patentowe nr P-388004.