A process of making a photopolymer printing plate includes steps of exposing a photopolymer material to light that is applied in a predetermined image pattern, washing the plate with a processing solution in order to cause polymeric material from portions of the plate that are determined by the image pattern to dissolve from the plate into the processing solution, and removing the dissolved polymeric material from the processing solution on the molecular level by ultrafiltration. The use of ultrafiltration permits the polymeric material to be efficiently recovered without the need for conventional recovery techniques such as distillation or flocculation, and allows reuse of the filtrate to process additional photopolymer plates. A system (10) for performing the process is also disclosed. The system is comprised of a plate making system (12), and an ultrafiltration system (24) with an ultrafilter (26) and a recirculation conduit (32).
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MAKING A PHOTOPOLYMER PRINTING PLATE.

FIELD OF THE INVENTION

This invention relates broadly to the commercial printing industry, and more specifically to systems of the photopolymer type for making printing plates.

DESCRIPTION OF THE RELATED TECHNOLOGY

Photopolymer printing technology, such as the FLEX-LITE SPLASH™ brand systems recently introduced by the owner of this invention, Polyfibron Technologies, Inc., involves making a flexographic printing plate by exposing a predetermined image onto a photosensitive polymeric material, which is then etched with a process solution to expose the image in a raised pattern on the printing plate. Polymer that is removed from the plate during the etching process becomes dissolved in a process or wash solution that is used to flush the printing plate.

Removing the dissolved polymer from the process solution is currently an expensive and laborious process, but one that is necessary for environmental reasons. Current processes to remove the dissolved polymer include distillation or chemical addition and flocculation of the polymer. Distillation units are costly and time consuming to operate. Flocculation involves the addition of a chemical such as borax to the solution, which raises the pH and renders the polymer insoluble in the washout solution. The stickiness of flocculated polymer, however, makes it very difficult to mechanically remove from the solvent; mechanical separators foul almost immediately.
It is clear that a long and unfilled need exists for an improved process and system for removing dissolved polymer from solution in a photopolymer printing plate making facility that is less laborious and expensive than the systems and processes that are currently in use.

**SUMMARY OF THE INVENTION**

Accordingly, it is an object of the invention to provide an improved process and system for removing dissolved polymer from solution in a photopolymer printing plate making facility that is less laborious and expensive than the systems and processes that are currently in use.

In order to achieve the above and other objects of the invention, an improved process of making a photopolymer printing plate includes steps of (a) exposing a photopolymer material to light that is applied in a predetermined image pattern; (b) washing the polymer with a processing solution in order to cause polymeric material from portions of the polymer that are determined by the image pattern to dissolve from the polymer into the processing solution; and (c) removing the dissolved polymeric material from the processing solution on the molecular level by ultrafiltration, whereby the polymeric material may be efficiently recovered without the need for conventional recovery techniques such as distillation or flocculation.

This allows the filtrate to be reused to process additional photopolymer plates.

An improved system for making and recovering effluent from a photopolymer printing plate includes, according to a second aspect of the invention, an exposure system for exposing a surface of a photopolymer material to light that is applied in a predetermined image pattern; a washout system for washing the unexposed polymer with a processing solution in order to cause polymeric material from portions of the polymer that are determined by the image pattern to dissolve from the surface into the processing solution; and an ultrafiltration system for removing the dissolved polymeric material from the
processing solution on the molecular level by ultrafiltration, whereby the polymeric material may be efficiently recovered without the need for conventional recovery techniques such as distillation or flocculation.

These and various other advantages and features of novelty which characterize the invention are pointed out with particularity in the claims annexed hereto and forming a part hereof. However, for a better understanding of the invention, its advantages, and the objects obtained by its use, reference should be made to the drawings which form a further part hereof, and to the accompanying descriptive matter, in which there is illustrated and described a preferred embodiment of the invention.

**BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1 is a schematic diagram depicting an improved system for recovering effluent from a photopolymer printing plate according to the preferred embodiment of the invention.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)**

Referring now to Figure 1, an improved system 10 for making a photopolymer type printing plate includes the actual plate making system 12, which includes, in an arrangement that is well known in this area of technology, an exposure system for exposing a photopolymer material plate to light that is applied in a predetermined image pattern, and a washout system for washing the plate with a processing solution in order to cause polymeric material from portions of the plate that are determined by the image pattern to dissolve from the plate into the processing solution. System 10 further includes a conduit 14 for passing the process solution that has the dissolved polymeric material therein to a holding tank 40, as may be seen in FIGURE 1. A fill control valve 16 having a float member 18 is provided in the conduit 14 to prevent over-filling of the holding tank 40. System 10 further includes,
as may also be seen in FIGURE 1, an ultrafiltration system 24 for removing the dissolved polymeric material from the processing solution on the molecular level by ultrafiltration, so that the polymeric material may be efficiently recovered without the need for conventional recovery techniques, such as distillation or flocculation. Ultrafiltration system 24 includes an intake conduit 22, through which processing solution is drawn from the tank 40 by means of pump 28 and forced into an intake port of an ultrafilter 26, as may also be seen in FIGURE 1. The pressure at the intake port of the ultrafilter 26 is monitored by a pressure gauge 30. A second, recirculation conduit 32 is communicated at a first end with a recirculation port of the ultrafilter 26, which is of the cross flow type, and at a second end with a holding tank 40. A pressure gauge 34 and temperature gauge 36 is interposed within the conduit 32, as may be seen in FIGURE 1. Ultrafilter 26 further has a permeate port to which a third conduit 38 is communicated, as may be seen in FIGURE 1. As is known in filtration technology, a large volume of processing fluid is circulated within one side of the ultrafilter 26 thorough the intake conduit 22 and the recirculation conduit 32. A relatively small amount of clean, filtered permeate fluid is emitted from the permeate port and is taken away for reuse by the permeate conduit 38.

The processing solution used in the plate making system 12 is preferably acidic, having a pH that is substantially within the range of 1.0 to 4.0, with a more preferred range of about 2.0 to 2.5 and a most preferred level of about 2.0. The temperature of the solution at the ultrafilter 26 is preferably within the range of about 75 to about 95 degrees Fahrenheit.

In the most preferred embodiment, plate making system 12 utilizes photo sensitized plates that are predominantly polyurethane, and that produce polymers in the processing solution that have a number average molecular weight (Mn) of about 29,500, and a weight average molecular
weight of about 80,200. The invention embraces the concept of using ultrafiltration to remove such molecules from the processing solution, meaning that a membrane having a nominal molecular weight cut-off of about 10,000 to about 40,000 could be used. However, the inventors have also discovered that, for unknown reasons, near perfect filtration can be achieved with a membrane that has a nominal molecular weight cut-off that is substantially greater than 40,000. This is a result of the product forming a second dynamic layer over the initial membrane material.

The inventors have determined that ultrafilter 26 can produce optimal filtration of the processing solution at a nominal molecular weight cut-off that is within the range of about 50,000 to about 100,000. Most preferably, filter 26 has a nominal molecular weight cut off of 60,000 to 70,000. A membrane having a nominal molecular weight cut off of 60,000 can be obtained as Model AES 100 from Advanced Membrane Technologies of San Diego, California. Advanced Membrane Technologies also supplies a membrane having a nominal molecular weight cut off of 70,000 under the Model Code AF 100. By increasing the nominal molecular weight cut off of the membrane that is used in ultrafilter 26, the flow capacity of ultrafilter 26 and the life of the membrane itself are increased when compared to a membrane that has a lower nominal molecular weight cut off. For example, it has been determined that an ultrafilter 26 based upon the Model AES 100 membrane described above will have a life of 1 year or greater, which is considered to be outstanding in this area of technology.

It is to be understood, however, that even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only, and changes may be made in detail, especially in matters of shape, size and arrangement of parts within the principles of the
invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.
WHAT IS CLAIMED IS:

1. An improved process of making a photopolymer printing plate, comprising steps of:
   (a) exposing a plate comprising photopolymer material to light that is applied in a predetermined image pattern;
   (b) washing the plate with a processing solution in order to cause polymeric material from portions of the plate that are determined by the image pattern to dissolve from the plate into the processing solution; and
   (c) removing the dissolved polymeric material from the processing solution on the molecular level by ultrafiltration, whereby the polymeric material may be efficiently recovered without the need for conventional recovery techniques such as distillation or flocculation.

2. A process according to claim 1, wherein step (c) is performed so as to remove substantially all of the polymeric material from the processing solution.

3. A process according to claim 1, wherein steps (b) and (c) are performed with a processing solution that is acidic.

4. A process according to claim 3, wherein steps (b) and (c) are performed with a processing solution that has a pH that is substantially within the range of 1.0 to 4.0.

5. A process according to claim 3, wherein steps (b) and (c) are performed with a processing solution that has a pH of about 2.0 to about 2.5.

6. A process according to claim 1, wherein step (c) is performed at a temperature that is substantially within the range of about 75 to 95 degrees Fahrenheit.
7. A process according to claim 1, wherein step (c) is performed with an ultrafiltration membrane that is designed to preclude passage therethrough of polymeric molecules having a weight average molecular weight of within the range of about 10,000 to about 100,000.

8. A process according to claim 7, wherein step (c) is performed with an ultrafiltration membrane that is designed to preclude passage therethrough of polymeric molecules having a weight average molecular weight of within the range of at least 50,000 to at least 100,000, but that, as a result of a dynamic layer that forms against the membrane, achieves excellent filtration of polymeric molecules having molecular weights of lower than 50,000.

9. A process according to claim 8, wherein step (c) is performed with an ultrafiltration membrane that is designed to preclude passage therethrough of substantially all polymeric molecules having a weight average molecular weight of at least 70,000.

10. A process according to claim 1, wherein step (c) is performed with an ultrafiltration membrane that is designed to preclude passage therethrough of substantially all polymeric molecules having a weight average molecular weight of about 70,000.

11. A process according to claim 1, wherein step (c) is performed with a filter that comprises polyether sulfone.
12. An improved system for recovering effluent from a photopolymer printing plate, comprising:
   exposure means for exposing a plate comprising photopolymer material to light that is applied in a
   predetermined image pattern;
   washout means for washing the surface with a processing solution in order to cause polymeric material from portions of the plate that are determined by the image pattern to dissolve from the plate into the processing
   solution; and
   ultrafiltration means for removing the dissolved polymeric material from the processing solution on the molecular level by ultrafiltration, whereby the polymeric material may be efficiently recovered without the need for conventional recovery techniques such as distillation or flocculation, and filtrate may be reused to process additional plates.

13. A system according to claim 12, wherein said ultrafiltration means is constructed and arranged to remove substantially all of the polymeric material from the processing solution.

14. A system according to claim 12, wherein said processing solution is acidic.

15. A system according to claim 14, wherein said processing solution has a pH that is substantially within the range of 1.0 to 4.0.

16. A system according to claim 14, wherein said processing solution has a pH of about 2.0 to about 2.5.

17. A system according to claim 11, wherein said ultrafiltration means operates at a temperature that is substantially within the range of about 75 to 95 degrees Fahrenheit.
18. A system according to claim 11, wherein said ultrafiltration means comprises an ultrafiltration membrane that is designed to preclude passage therethrough of polymeric molecules having a weight average molecular weight of within the range of at about 10,000 to about 100,000.

19. A system according to claim 18, wherein said ultrafiltration membrane is designed to preclude passage therethrough of polymeric molecules having a weight average molecular weight of within the range of at least 50,000 to at least 100,000, but that, as a result of a dynamic layer that forms against the membrane, achieves excellent filtration of polymeric molecules having molecular weights of lower than 50,000.

20. A system according to claim 19, wherein said ultrafiltration means comprises an ultrafiltration membrane that is designed to preclude passage therethrough of substantially all polymeric molecules having a weight average molecular weight of at least 70,000.

21. A system according to claim 12, wherein said ultrafiltration means comprises an ultrafiltration membrane that is designed to preclude passage therethrough of substantially all polymeric molecules having a weight average molecular weight of about 70,000.

22. A system according to claim 12, wherein said ultrafiltration means comprises a filter that comprises polyether sulfone.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : G03F 7/30
US CL: 430/306, 309; 210/654, 650, 651, 251, 500, 41, 908

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)


Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

none

Electronic database consulted during the international search (name of data base and, where practicable, search terms used)

USPTO APS "Printing and recycling and (ultrafiltration or ultrafiltration); "Photoresist # and Recycl and (Ultra Filtration)."

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>US-A, 5,328,805 (Huynh-Tran et al) 12 July 1994, Abstract, column 6, lines 32-53, column 7, lines 29-55; column 14, lines 33-52, EXAMPLE 1.</td>
<td>1,3-5, 14-16</td>
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<td>US-A, 4,239,368 (Krause et al) 16 December 1980, see Figure 1, claims, abstract.</td>
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Further documents are listed in the continuation of Box C. See patent family annex.

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Date of actual completion of the international search

16 AUGUST 1996

Date of mailing of the international search report

24 OCT 1996

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<td>US, A, 5,124,736 (Yamamoto et al) 23 June 1992, see Figure 1a, columns 3-4.</td>
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<td>WO, A1, 96/06382 (Seeley et al) 29 February 1996, see Abstract and claims.</td>
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