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(54) Title: FLUSHING COMPOSITION

(57) Abstract: A flushing composition for a radiation-curing printing apparatus comprising a radiation-curable (meth)acrylate monomer having a volatile organic compound (VOC) content of less than 100 g/L as measured by EPA Method (24).



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Flushing composition

This invention relates to a flushing composition for a radiation-curing printing apparatus, and in particular to a flushing composition for use with a UV-curing ink-jet printer.

In radiation-curing printing processes, an ink comprising a curable monomer, a photoinitiator and optionally other conventional components is applied to a substrate. The ink is cured or hardened by irradiating the ink with actinic radiation, such as UV light, which causes the monomer to polymerise (cure). In screen printing processes the ink is applied to a fine mesh screen which has areas blocked with a non-permeable material to form a stencil. Ink passes through the screen in the areas that are not blocked, and forms a pattern on a substrate placed under the screen. The screen can be made of stainless steel metal mesh, for example. During the printing process, dried and/or cured ink can build up on the screen which can lead to a loss of print accuracy and contamination of inks. It is therefore necessary periodically to clean the screens in order to remove the residual ink. In ink-jet printing processes, minute droplets of black, white or coloured ink are ejected in a controlled manner from one or more reservoirs or printing heads through narrow nozzles on to a substrate which is moving relative to the reservoirs. During the printing process, residual ink may collect on the nozzle plate which means that the nozzle plate must be cleaned periodically in order to maintain printing quality.

Flushing compositions are used to remove residual ink from radiation-curing printing apparatus. A flushing composition should be a good solvent for the ink and, for radiation-curing printing processes in particular, the flushing composition should preferably be able to remove cured or dried ink from the printing apparatus. A flushing composition should also be compatible with the ink in order to avoid precipitation of ink vehicle components or flocculation of the ink pigment. Such precipitation and/or flocculation may lead to clogging of the screen or print head which could lead to a loss of print quality, or damage to the printing apparatus. Flushing compositions can be applied manually, for example by applying the flushing composition to a cloth and wiping the print head or screen clean. Alternatively, the

flushing composition can be sprayed directly on to the print head or screen during an automatic cleaning cycle.

Current flushing compositions for radiation-curable inks are generally based on high-boiling glycol ethers or their acetate esters, for example tripropylene glycol monomethyl ether (TPM). TPM has good cleaning abilities and does not cause precipitation or flocculation of ink components. TPM is slow-drying, however. This means that prints made immediately after cleaning can be of poor quality due to contamination of the ink with slow-drying glycol solvent. Furthermore, recent legislation in California and other US states requires that any composition used for cleaning in a UV-cured printing operation must have a volatile organic compound (VOC) content of less than 100 g/L measured using the US Environmental Protection Agency Reference Method 24 (EPA Method 24). The legislation has recently been revised to reduce the VOC limit even further to 25 g/L. This revision is expected to take effect some time in the future. Since TPM has a VOC content of 965 g/L (or 100% VOC), alternative flushing compositions must be found.

Possible alternative flushing solvents include acetone and soy oil. Acetone is exempt from the California VOC regulations but is highly flammable and may cause pigment flocculation in UV-curable inks. Soy oil is a low VOC solvent but it has poor solvency for inks. Methyl acetate has also been suggested as an alternative flushing composition. Methyl acetate is exempt from the VOC legislation but this solvent is flammable and forms toxic methyl alcohol as a metabolite.

Other alternative flushing solvents include water-based cleaners such as Spray Clean 12 available from Applied Cleaning Technologies. Although water-based cleaners generally have a low VOC content and low toxicity, the compatibility with ink can be very poor, leading to precipitation and flocculation of ink components. Furthermore, some ink-jet print heads are not designed to tolerate water.

30

There is therefore a requirement for alternative flushing compositions that overcome the disadvantages discussed above.

It has surprisingly been found that radiation-curable monomers can be used as flushing compositions for a radiation-curing printing apparatus and in a first embodiment the present invention therefore provides the use of a composition comprising a radiation-curable (meth)acrylate monomer having a volatile organic
5 compound (VOC) content of less than 100 g/L as measured by EPA Method 24 as a flushing composition for a radiation-curing printing apparatus.

In a second embodiment the present invention provides the use of a composition comprising a radiation-curable (meth)acrylate monomer having a molecular weight of
10 340 to 600 as a flushing composition for a radiation-curing printing apparatus.

By “flushing composition” is meant a composition that is used to clean residual ink from a printing apparatus. Flushing compositions are also known as “flushing solution”, “cleaning solution”, “flush” or “head wash”.
15

The compositions used according to the present invention provide excellent solvency for radiation-curable inks and are therefore highly effective cleaners of printing apparatus. Furthermore, the compositions are compatible with inks, and do not lead to precipitation and flocculation of the ink components. In addition, the flushing
20 compositions used according to the invention do not compromise printing performance in prints made immediately after cleaning. This is because any radiation-curable (meth)acrylate monomer that contaminates the ink is simply cured when the ink is irradiated, which means that no slow-drying solvent is left in the ink. Finally, the flushing compositions are not highly flammable and are therefore safe to
25 use in a commercial environment.

Some modern radiation-curing ink-jet printers comprise an automatic cleaning system which sprays a flushing composition on to the nozzle plate. In some processes, the flush/ink mixture is removed from the plate using a vacuum assembly. In order for a
30 flushing composition to be suitable for use in a vacuum assembly, the composition must have a relatively low viscosity. However, the requirement for a flushing composition to have a low viscosity often conflicts with the requirement for a low VOC content, or low flammability. There therefore exists a need for flushing compositions that overcome the disadvantages discussed previously, and that can be

used in an automatic cleaning system comprising a vacuum removal step. The inventors have surprisingly found that the use of specific combination of radiation-curable monomers provides a flushing composition that is suitable for use in an automatic cleaning system. In a preferred embodiment the invention therefore
5 provides the use as described in the first or second embodiments wherein the composition additionally comprises a second radiation-curable (meth)acrylate monomer having a viscosity of less than 20 mPas at 25°C.

The compositions used in this preferred embodiment of the invention provide a
10 particularly advantageous combination of properties. In particular, the preferred compositions are suitable for use in automatic cleaning systems that use a vacuum removal assembly, but they also demonstrate the advantageous properties described above. The inventors also surprisingly found that the use of a second radiation-curable (meth)acrylate monomer as defined above results in an improvement in
15 cleaning ability. Without intending to be bound by theory, the improvement is thought to be due to the second radiation-curable (meth)acrylate monomer lowering the surface tension and therefore increasing the wetting power of the composition.

The invention also provides a flushing composition for a radiation-curing printing
20 apparatus, said composition consisting essentially of at least one first radiation-curable (meth)acrylate monomer having a volatile organic content of less than 100 g/L as measured by EPA Method 24, at least one second radiation-curable (meth)acrylate monomer having a viscosity of less than 20 mPas at 25°C, and a UV inhibitor.

25 In an alternative embodiment the invention provides a flushing composition for a radiation-curing printing apparatus, said composition consisting essentially of at least one first radiation-curable (meth)acrylate monomer having a molecular weight of 340 to 600, at least one second radiation-curable (meth)acrylate monomer having a
30 viscosity of less than 20 mPas 25°C, and a UV inhibitor.

The compositions used according to the present invention comprise a radiation-curable (meth)acrylate monomer having a VOC content of less than 100g/L as measured by EPA Method 24 and/or a molecular weight of 340 to 600. Throughout

the description of the invention this monomer will be referred to as the first radiation-curable (meth)acrylate monomer. In a preferred embodiment of the invention, the composition additionally comprises a monomer having a viscosity of less than 20 mPas at 25°C. This monomer will be referred to as the second radiation-curable
5 (meth)acrylate monomer. The first radiation curable monomer and the second radiation curable monomer are different.

By “radiation-curable monomer” is meant a monomer that is capable of polymerising upon exposure to radiation, for example UV radiation, in the presence of a
10 photoinitiator, to provide a hardened or cured material. By “(meth)acrylate monomer” is meant an acrylate and/or methacrylate monomer.

The first radiation-curable (meth)acrylate monomer will be described in further detail. (Meth)acrylate monomers are widely available. Any (meth)acrylate monomer that
15 has a VOC content of less than 100 g/L as measured by EPA Method 24 and/or a molecular weight of 340 to 600 can be used as the first monomer in the present invention. Suitable monomers are commercially available or can be made by methods known in the art.

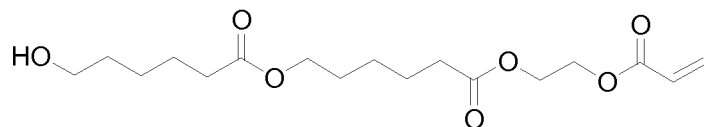
20 Preferably the first radiation-curable (meth)acrylate monomer has a VOC content less than 50 g/L as measured by EPA Method 24, most preferably less than 20 g/L.

The first radiation-curable (meth)acrylate monomer preferably has a viscosity of less than or equal to 100 mPas at 25 °C, more preferably less than or equal to 80 mPas and
25 most preferably from 20 mPas to 75 mPas at 25 °C.

The first monomer is preferably a monofunctional monomer or a difunctional monomer although multifunctional monomers can also be used. By “monofunctional monomer” is meant a monomer having one polymerisable group per monomer
30 molecule. A “difunctional monomer” has two polymerisable groups per monomer molecule. Acrylate monomers are preferred. The monomer can comprise branched or cyclic groups or have a linear structure. Monomers having a “linear structure” comprise one or more polymerisable groups bonded to a linear group. In other words, the monomer comprises no branched or cyclic groups.

The first radiation-curable (meth)acrylate monomer preferably comprises one or more oxygen atoms in addition to those found in the (meth)acrylate polymerisable group(s). In particular, the first monomer preferably comprises at least one ether, carbamate or an additional ester group. By “ether group” is meant $-R-O-R_1-$ wherein R and R_1 are divalent hydrocarbyl groups having 1 to 6 carbon atoms. By “carbamate group” is meant $-R_2-HN-C(O)-O-R_3-$ wherein R_2 and R_3 are divalent hydrocarbyl groups having 1 to 6 carbon atoms. By “ester group” is meant $-R_4-C(O)-O-R_5-$ wherein R_4 and R_5 are divalent hydrocarbyl groups having 1 to 6 carbon atoms. Acrylate and methacrylate monomers comprise an ester of acrylic or methacrylic acid. Where the discussion herein refers to an additional ester group, it is taken to mean an ester group in addition to the ester that forms part of the (meth)acrylate group.

Examples of first monomers include caprolactone acrylate, which has the following structure:



and urethane monoacrylates such as Ebecryl 1040 sold by Cytec, Inc.

A particularly preferred first monomer comprises an alkoxy group of the formula $-(CH(R_6)-CH_2-O)_n-$ wherein R_6 is hydrogen or methyl and n has an average value of 1 to 15, preferably 2 to 10. Examples of this type of monomer include polyethylene glycol (meth)acrylates and di(meth)acrylates and 1 to 4 molar alkoxyated C_1 to C_8 alkanediol diacrylates. An example of the latter is 1 to 2 molar alkoxyated hexanediol diacrylate (alkoxyated HDDA), preferably 1 to 2 molar ethoxyated hexanediol diacrylate. Suitable alkoxyated hexane diol diacrylates include CD564 and CD561, obtainable from Sartomer. Polyethylene glycol (PEG) diacrylates are preferred, particularly polyethylene glycol (200) diacrylate and polyethylene glycol (400) diacrylate. Polyethylene glycol (200) diacrylate is most preferred.

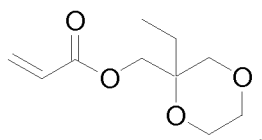
The compositions used according to the present invention may comprise one or a mixture of two or more of the first monomers described above.

5 The second radiation-curable (meth)acrylate monomer will be described in further detail. Any (meth)acrylate monomer that has a viscosity of less than 20 mPas at 25°C can be used as a second monomer in the present invention. Suitable monomers are commercially available or can be made by methods known in the art.

10 The second radiation-curable (meth)acrylate monomer has a viscosity at 25 °C that is lower than the viscosity of the first radiation-curable (meth)acrylate monomer at 25 °C. The viscosity of the second radiation-curable (meth)acrylate monomer at 25 °C is preferably at least 5 mPas lower than the viscosity of the first radiation-curable (meth)acrylate monomer at 25 °C, more preferably at least 10 mPas lower, and more preferably at least 15 mPas lower.

15 The second monomer is preferably a monofunctional monomer or a difunctional monomer although multifunctional monomers can also be used. Acrylate monomers are preferred. The second radiation-curable (meth)acrylate monomer can include branched, cyclic or linear groups.

20 One preferred type of second monomer comprises an ether group wherein “ether” is as defined above. This preferred type of monomer preferably includes branched and/or cyclic groups. Examples of this preferred type of monomer include propoxylated (2) neopentyl glycol diacrylate (neopentyl glycol DA (2-PO)) and cyclic
25 trimethylolpropane formal acrylate:



30 Propoxylated (2) neopentyl glycol diacrylate is particularly preferred.

An alternative, and most preferred type of second monomer comprises a linear C₄-C₁₄ alkyl or a linear C₄-C₁₄ alkylene group. Particularly preferred monomers include C₈-

C₁₄ linear alkyl monoacrylates and C₄-C₈ linear alkylene diacrylates, preferably lauryl acrylate, octyl/decyl acrylate, tridecyl acrylate or 1,6 hexanediol diacrylate (1,6 HDDA), most preferably tridecyl acrylate.

- 5 By “C₄-C₁₄ alkyl” is meant a monovalent alkyl radical comprising 4 to 14 carbon atoms. “C₄-C₁₄ alkylene” is a divalent alkylene radical comprising 4 to 14 carbon atoms.

10 The compositions used according to the present invention may comprise one or a mixture of two or more of the second monomers described above.

The composition used according to the present invention preferably comprises greater than 75 weight percent, more preferably greater than 85 weight percent and most preferably greater than 95 weight percent of radiation-curable (meth)acrylate monomer based on the total weight of the composition. The compositions used according to the invention may comprise greater than 75 weight percent, more preferably greater than 85 weight percent and most preferably greater than 95 weight percent of at least one first radiation-curable (meth)acrylate monomer.

20 Alternatively, when the compositions used according to the invention comprise a second radiation-curable (meth)acrylate monomer, then the total amount of first and second radiation-curable (meth)acrylate monomer preferably comprises greater than 75 weight percent, more preferably greater than 85 weight percent and most preferably greater than 95 weight percent, based on the total weight of the composition.

30 The compositions used according to the invention may include additional components such as secondary cleaning agents, surfactants, defoamers, stabilisers against deterioration by heat or light, solvents and biocides. The compositions used according to the present invention preferably comprise a photoinhibitor. The photoinhibitor is preferably added in a trace amount. By “photoinhibitor” is meant a stabiliser that prevents deterioration of the composition by incident actinic radiation, particularly UV light.

The compositions preferably comprise less than 10% by weight of water, more preferably less than 5%. Most preferably the compositions are substantially free of water.

- 5 Preferably, the compositions used according to the invention consist essentially of at least one first radiation-curable (meth)acrylate monomer as defined above and a UV inhibitor. Preferably, the compositions used according to the invention consist of at least one first radiation-curable (meth)acrylate monomer as defined above and a UV inhibitor. Alternatively, preferred compositions used according to the invention
10 consist essentially of at least one first radiation-curable (meth)acrylate monomer as defined above, at least one second radiation-curable (meth)acrylate monomer as defined above, and a UV inhibitor. Preferably, the compositions used according to the invention consist of at least one first radiation-curable (meth)acrylate monomer as defined above, at least one second radiation-curable (meth)acrylate monomer as
15 defined above and a UV inhibitor.

“Consisting essentially of” is taken to mean that in addition to those components which are stated to be mandatory, other components may also be present in the composition, provided that the essential characteristics of the composition are not
20 materially affected by their presence.

Preferred compositions used according to the present invention comprise 75 to 97 weight percent, preferably 85 to 95 weight percent, and most preferably about 90 weight percent of said first radiation-curable (meth)acrylate monomer, and 3 to 25
25 weight percent, preferably 5 to 15 weight percent and most preferably about 10 weight percent of second radiation-curable (meth)acrylate monomer, based on the total weight of radiation-curable monomer.

The compositions used according to the present invention can comprise any
30 combination of first and second monomer described above. Preferred compositions comprise a first monomer comprising an alkoxy group of the formula $-(CH(R_6)-CH_2-O)_n-$ wherein R_6 is hydrogen or methyl and n has an average value of 1 to 15, preferably 2 to 10, and a second monomer comprising a linear C_4 - C_{14} alkyl or linear C_4 - C_{14} alkylene group. Particularly preferred combinations comprise a

polyethylene glycol (meth)acrylate such as polyethylene glycol (200) diacrylate or polyethylene glycol (400) diacrylate, and a C₈-C₁₄ linear alkyl monoacrylate such as lauryl acrylate, octyl/decyl acrylate or tridecyl acrylate, preferably tridecyl acrylate. The most preferred combination of first and second monomers comprises
5 polyethylene glycol (200) diacrylate and tridecyl acrylate. A highly preferred composition used according to the invention comprises about 90 weight percent of polyethylene glycol (200) diacrylate and about 10 weight percent of tridecyl acrylate, based on the total weight of monomer.

10 The present invention provides the use of compositions comprising a radiation-curable (meth)acrylate monomer as flushing compositions for a radiation-curing printing apparatus. The compositions described in the present application can be used as flushing compositions for any radiation-curing printing apparatus such as printing screens and ink-jet printers. The compositions can be applied to the printer apparatus
15 manually, for example by applying the composition to a cloth and wiping the apparatus clean. Many modern ink-jet printers provide an automatic cleaning system, however, and the compositions can advantageously be used in these automatic cleaning systems. Some automatic cleaning systems comprise a spraying nozzle that coats the nozzle plate with cleaning solution, and a vacuum nozzle that removes said
20 composition along with the dissolved ink and other dirt.

The compositions described herein are preferably used to clean UV-curable ink-jet printers, most preferably UV-curable ink-jet printers that use an acrylate-containing, UV-curable ink.

25

The invention also provides flushing compositions per se. In particular, the present invention provides a flushing composition for a radiation-curing printing apparatus, said composition consisting essentially of at least one first radiation-curable (meth)acrylate monomer having a VOC content of less than 100 g/L as measured by
30 EPA Method 24, at least one second radiation-curable (meth)acrylate monomer having a viscosity of less than 20 mPas at 25°C, and a UV inhibitor.

The present invention also provides a flushing composition for a radiation-curing printing apparatus, said composition consisting essentially of at least one first

radiation-curable (meth)acrylate monomer having a molecular weight of 340 to 600, at least one second radiation-curable (meth)acrylate monomer having a viscosity of less than 20 mPas at 25°C, and a UV inhibitor.

- 5 The preferred monomers, monomer combinations and relative amounts of first and second monomers provided in the flushing compositions of the invention are as described above.

10 Viscosity may be measured using a digital Brookfield viscometer fitted with a thermostatically controlled cup and spindle arrangement and a ULVA, or ultra-low-viscosity adapter, such as model LVDV-1. The spindle used with this ULVA is S00 and the spindle speed is 12 to 60 rpm, for example 40 rpm.

15 United States Environmental Protection Agency Reference Method 24 (Code of Federal Regulations, Title 40, Part 60, Appendix A) provides a method for determining the volatile matter content, water content, density, volume solids, and weight solids of surface coatings. This method allows the VOC content to be measured indirectly. The total volatile matter content is determined using ASTM D2369 or ASTM D5403. Other ASTM methods (as specified in Method 24) are used
20 to measure the amount of water and exempt solvents, and these are subtracted from the total volatile matter to give the VOC content.

Examples

- 25 Viscosity, VOC content and surface tension data for examples of monomers suitable for use in the present invention and for TPM are provided in Table 1 below. Viscosities are provided by the supplier unless stated otherwise.

TABLE 1

Monomer	Name	Supplier	Viscosity 25 °C /mPas	@	VOC content by EPA Method 24 / g/L	Surface Tension / mNm ⁻¹
PEG 400 Diacrylate	SR344	Rahn	65 (measured)		11.2	42.6
PEG 200 Diacrylate	SR259	Sartomer	21.5		16.8	41.3
Alkoxyated HDDA	CD561	Sartomer	46		17.1	-
Alkoxyated HDDA	CD564	Sartomer	33.4 (measured)		38.4	-
Caprolactone Acrylate	SR495	Sartomer	80		73.7	42.9
Tridecyl Acrylate	SR489D	Sartomer	4.7		83.7	28.9
Neopentyl Glycol DA (2- PO)	NPG(PO)DA	Cytec	15.4 (measured)		266	32.8
1,6 HDDA	SR-238	Sartomer	9		508	35.7
Lauryl Acrylate	M30225	Cytec	6		761	30.3
Octyl/Decyl Acrylate	M30210	Cytec	4		879.5	-
TPM	QU017	Sericol	6		965	-

Table 2 shows a comparison of the properties of known flushing compositions and compositions of the invention. Percentages are weight percentages.

TABLE 2

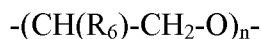
5

	Composition	Viscosity @ 25 °C / mPas	VOC content by EPA Method 24 / g/L	Ink compatibility	Flash point
Example 1	100% PEG 200 diacrylate	21.5	16.8	N/A	N/A
Example 2	90% PEG 200 diacrylate 10% tridecyl acrylate	16.4	N/A	Excellent	93°C
Example 3	90% PEG 400 diacrylate 10% neopentyl glycol DA (2- PO)	45.8	N/A	Excellent	93 °C
Comparative Example 1	Acetone	0.36	(exempt from California VOC regulations)	Very poor	-20°C
Comparative Example 2	Soy oil	>50	N/A	Poor	>175°C
Comparative Example 3	TPM	6	964	Excellent	110°C

The compositions of Examples 1 to 3 provide good cleaning efficiency and are suitable for use in an automatic cleaning system with vacuum assembly.

CLAIMS

1. Use of a composition comprising a radiation-curable (meth)acrylate monomer having a volatile organic compound (VOC) content of less than 100 g/L as measured by EPA Method 24, as a flushing composition for a radiation-curing printing apparatus.
5
2. Use of a composition comprising a radiation-curable (meth)acrylate monomer having a molecular weight of 340 to 600 as a flushing composition for a radiation-curing printing apparatus.
10
3. Use as claimed in claim 1 wherein said radiation-curable (meth)acrylate monomer has a molecular weight of 340 to 600
4. Use as claimed in any preceding claim wherein said radiation-curable (meth)acrylate monomer has a VOC content of less than 50 g/L, more preferably less than 20 g/L, as measured by EPA Method 24.
15
5. Use as claimed in any preceding claim wherein said radiation-curable monomer is a UV-curable monomer.
20
6. Use as claimed in any preceding claim wherein said radiation-curable monomer is a monofunctional monomer or a difunctional monomer.
7. Use as claimed in any preceding claim wherein said radiation-curable monomer additionally comprises at least one ether or carbamate group or at least one additional ester group.
25
8. Use as claimed in any preceding claim wherein said radiation-curable monomer is caprolactone acrylate.
30
9. Use as claimed in any one of claims 1 to 6 wherein said monomer comprises a



group, wherein R_6 is hydrogen or methyl and n has an average value of 1 to 15,
preferably 2 to 10.

10. Use as claimed in claim 9 wherein said radiation-curable monomer is polyethylene glycol (200) diacrylate, polyethylene glycol (400) diacrylate or an alkoxyated hexanediol diacrylate, preferably polyethylene glycol (200) diacrylate.

11. Use as claimed in any preceding claim wherein said composition additionally comprises a UV inhibitor.

12. Use as claimed in any preceding claim wherein said composition comprises greater than 75 weight percent, preferably greater than 85 weight percent and most preferably greater than 95 weight percent of said radiation-curable monomer, based on the total weight of the composition.

13. Use as claimed in any one of claims 1 to 11 wherein said composition additionally comprises a second radiation-curable (meth)acrylate monomer having a viscosity of less than 20 mPas at 25°C.

14. Use as claimed in claim 13 wherein the viscosity of said second radiation-curable (meth)acrylate monomer at 25 °C is at least 5 mPas lower than the viscosity of the first radiation-curable (meth)acrylate monomer at 25 °C, preferably at least 10 mPas lower, more preferably at least 15 mPas lower.

15. Use as claimed in claim 13 or claim 14 wherein said second radiation-curable monomer is a UV-curable monomer.

16. Use as claimed in any one of claims 13 to 15 wherein said second radiation-curable monomer is a monofunctional monomer or a difunctional monomer.

17. Use as claimed in any one of claims 13 to 16 wherein said second radiation-curable monomer has a linear structure.

5 18. Use as claimed in any one of claims 13 to 17 wherein said second radiation-curable monomer comprises a C₄-C₁₄ linear alkyl or a C₄-C₁₄ linear alkylene group.

10 19. Use as claimed in any one of claims 13 to 18 wherein said second radiation-curable monomer is a C₈-C₁₄ linear alkyl monoacrylate or a C₄-C₈ linear alkylene diacrylate.

15 20. Use as claimed in any one of claims 13 to 19 wherein said second radiation-curable monomer is lauryl acrylate, octyl/decyl acrylate, tridecyl acrylate or 1,6 hexanediol diacrylate, preferably tridecyl acrylate.

20 21. Use as claimed in any one of claims 13 to 16 wherein said second radiation-curable monomer is propoxylated (2) neopentyl glycol diacrylate or cyclic trimethylolpropane formal acrylate, preferably propoxylated (2) neopentyl glycol diacrylate .

25 22. Use as claimed in any one of claims 13 to 21 wherein the total amount of radiation-curable monomer present in said composition is greater than 75 weight percent, preferably greater than 85 weight percent and most preferably greater than 95 weight percent, based on the total weight of the composition.

30 23. Use as claimed in any one of claims 13 to 22 wherein said composition comprises 75 to 97 weight percent of at least one radiation-curable monomer as defined in any one of claims 1 to 10, and 3 to 25 weight percent of at least one second radiation-curable monomer as defined in any one of claims 13 to 21, based on the total weight of radiation-curable monomer.

24. Use as claimed in any preceding claim wherein said composition comprises less than 10% by weight of water, preferably less than 5% by weight of water.

25. Use as claimed in any preceding claim wherein said composition is substantially free of water.

5 26. Use as claimed in any preceding claim wherein said radiation-curing printing apparatus is an ink-jet printer.

10 27. A flushing composition for a radiation-curing printing apparatus, said composition consisting essentially of at least one first radiation-curable (meth)acrylate monomer having a volatile organic compound (VOC) content of less than 100 g/L as measured by EPA Method 24, at least one second radiation-curable (meth)acrylate monomer having a viscosity of less than 20 mPas at 25 °C, and a UV inhibitor.

15 28. A flushing composition for a radiation-curing printing apparatus, said composition consisting essentially of at least one first radiation-curable (meth)acrylate monomer having a molecular weight of 340 to 600, at least one second radiation-curable (meth)acrylate monomer having a viscosity of less than 20 mPas at 25 °C, and a UV inhibitor.

20 29. A flushing composition as claimed in claim 27 or claim 28 wherein said first radiation-curable (meth)acrylate monomer is as defined in any one of claims 3 to 10.

25 30. A flushing composition as claimed in any one of claims 27 to 29 wherein said second radiation-curable (meth)acrylate monomer is as defined in any one of claims 14 to 21.

30 31. A flushing composition as claimed in any one of claims 27 to 30 comprising 75 to 97 weight percent of at least one first radiation-curable (meth)acrylate monomer, and 3 to 25 weight percent of at least one second radiation-curable (meth)acrylate monomer, based on the total weight of radiation-curable monomer.

32. A flushing composition as claimed in any one of claims 27 to 31 comprising 85 to 95 weight percent of at least one first radiation-curable (meth)acrylate monomer, and 5 to 25 weight percent of at least one second radiation-curable (meth)acrylate monomer, based on the total weight of radiation-curable monomer.

33. A flushing composition as claimed in any one of claims 27 to 32 comprising about 90 weight percent of at least one first radiation-curable (meth)acrylate monomer, and about 10 weight percent of at least one second radiation-curable (meth)acrylate monomer, based on the total weight of radiation-curable monomer.

34. A flushing composition as claimed in any one of claims 27 to 33 wherein said composition consists essentially of about 90 weight percent of polyethylene glycol (200) diacrylate, and about 10 weight percent of tridecyl acrylate based on the total weight of radiation-curable monomer; and a UV inhibitor.

35. Use as claimed in claim 1 or claim 2 wherein the flushing composition is as defined in any one of claims 27 to 34.

36. A method of cleaning a piezo-inkjet nozzle plate comprising applying a flushing composition as defined in any one of claims 27 to 34 to the nozzle plate.

37. The method of claim 36 comprising spraying the flushing composition on to the nozzle plate.

38. The method according to claim 37 wherein the flushing composition is removed from the nozzle plate by vacuum.

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2009/050025

A. CLASSIFICATION OF SUBJECT MATTER

INV. B41J2/165 C11D3/37 C11D11/00

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)

C11D B41J

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 621 348 A (TOSHIBA TEC KK [JP]) 1 February 2006 (2006-02-01) paragraph [0035] - paragraph [0036]; claim 1	1-38
A	EP 1 837 182 A (FUJIFILM CORP [JP]) 26 September 2007 (2007-09-26) paragraph [0218]	1-38
A	US 2003/092820 A1 (SCHMIDT KRIS ALAN [US] ET AL) 15 May 2003 (2003-05-15) paragraph [0027] - paragraph [0031]; claims 1-28	27-34
P, A	EP 1 955 850 A (FUJIFILM CORP [JP]) 13 August 2008 (2008-08-13) paragraph [0473] - paragraph [0478]	1-38
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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O document referring to an oral disclosure, use, exhibition or other means

P document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

Z document member of the same patent family

Date of the actual completion of the international search

29 April 2009

Date of mailing of the international search report

08/05/2009

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INTERNATIONAL SEARCH REPORT

International application No

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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