

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
25 September 2003 (25.09.2003)

PCT

(10) International Publication Number
WO 03/078536 A2

- (51) International Patent Classification⁷: **C09J**
- (21) International Application Number: PCT/US03/06709
- (22) International Filing Date: 17 March 2003 (17.03.2003)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
60/364,133 15 March 2002 (15.03.2002) US
- (71) Applicant (for all designated States except US): **ADHESIVES RESEARCH, INC.** [US/US]; P.O. Box 100, Glen Rock, PA 17327 (US).
- (72) Inventors; and
- (75) Inventors/Applicants (for US only): **XIA, Wilson, Z.** [AU/US]; 20 Bridlewood Way, York, PA 17402 (US). **HARIHARAN, Deepak** [IN/US]; 65 Governors Place at Waterford, York, PA 17402 (US). **KRUPA, David, A.** [US/US]; 100 Poplar Lane, Mt. Wolf, PA 17347 (US).
- (74) Agent: **HELLWEGE, James, W.**; BIRCH, STEWART, KOLASCH & BIRCH, LLP, P.O. Box 747, Falls Church, VA 22044 (US).
- (81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.
- (84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— without international search report and to be republished upon receipt of that report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.



WO 03/078536 A2

(54) Title: PRESSURE SENSITIVE ADHESIVE FOR USE IN VIBRATION/SOUND-DAMPING

(57) Abstract: A pressure sensitive adhesive is provided comprised of the following composition: (A) a copolymer comprised of the polymerization reaction product of: (1) an alkyl (meth)acrylate monomer having a T_g > 20 °C.; (2) optionally a C1-30 (meth)acrylate monomer; (3) optionally a nitrogen-containing polar monomer; and (4) optionally a polymerizable epoxy-containing monomer, said monomers being present in an amount such that the T_g of said copolymer (A) is greater than about -2 °C; and (B) a copolymer comprised of the polymerization reaction product of: (1) optionally vinyl acetate or vinyl ether; (2) (C2-12)alkyl(meth)acrylate; (3) hydroxy(C1-5)alkyl(meth)acrylate; and (4) optionally a polymerizable epoxy-containing monomer, said monomers being present in an amount such that the T_g of said copolymer (B) is less than about -20 °C, and wherein said copolymers (A) and (B) are present in said composition in a weight ratio ranging from about 0:100 to about 60:40, preferably about 5:95 to about 60:40.

“Pressure Sensitive Adhesive For Use in Vibration/Sound-Damping”

BACKGROUND OF THE PRESENT INVENTION

The present invention is directed to an ultra-clean pressure sensitive adhesive composition for use in vibration/sound-damping.

A quiet operating environment is often highly desirable in the high performance computer and PC gaming systems. Computer systems generally include at least one or more disk drives for storage of information. Such disk drives are generally in the form of a sealed head-disk assembly chamber which includes one or more disks stacked on a spindle motor hub. The acoustic noise of a disk drive arises from the spindle motor and disks (“Idle Acoustics”) and from the moving actuator that supports the read/write heads (“Seek Acoustics”). On the other hand, during operation of the disk drives, vibration at various frequencies also occurs as a result of the mechanical resonance of the various components of the sealed head-disk assembly. It is thus desirable to provide means to damp vibration/sound resulting from operation of such devices.

The problem of vibration/sound-damping is not, however, restricted to computer systems. Such problems also exist in the automobile industry as well as conventional appliances, as well as any other application requiring the use of motors or related vibration or sound-inducing mechanisms.

Many attempts have been made to address this problem. See, for example, U.S. Patent Nos. 4,942,187 (vibration-damping rubber composition of hexene-1 type polymer and Si-containing graft copolymer and inorganic

reinforcing agent); 5,279,896 (mechanical design for disk drive vibration and noise damping); 5,464,659 (vibration damping material comprised of acrylic monomers, silicone adhesive, and optional crosslinker); 5,781,373 (soft metal substrate for disk drive noise reduction); 5,858,521 (vibration damping material of a laminate of a viscoelastic layer and a hardenable pressure sensitive adhesive layer); 5,939,179 (vibration damping material comprised of one surface of a rigid body and a polymer layer of synthetic rubber); and 6,216,817 (preparation of damping coating by photopolymerization); U.S. published patent application No. 20010044023 (vibration attenuating article having a non-tacky film covering substantially all of the article); and EP 390207 (vibration damping material comprised of blend of fluorine-containing polymer and acrylic polymer). Such attempts have not always been successful. For example, in the computer industry, any material used in connection with the computer hardware must be low-volatile and non-corrosive in nature (i.e., ultra-clean). Conventional adhesives have not generally satisfied this requirement. The adhesive material which is employed must also provide vibration/sound-damping over a wide frequency range, possess both cold flow and heat resistance, and provide high adhesion and good strippability.

OBJECTS AND SUMMARY OF THE PRESENT INVENTION

It is accordingly an object of the present invention to provide a pressure sensitive adhesive composition that may be used in vibration/sound damping applications.

It is also an object of the present invention to provide an ultra-clean composition that exhibits pressure sensitive adhesive properties.

In accordance with the present invention, there is provided a pressure sensitive adhesive comprised of the following:

(A) a copolymer comprised of the polymerization reaction product of an alkyl (meth)acrylate monomer having a $T_g > 20\text{ }^\circ\text{C}$, optionally a C_{1-30} (meth)acrylate monomer, optionally a nitrogen-containing polar monomer, and optionally a polymerizable epoxy-containing monomer, said monomers being present in an amount such that the T_g of said copolymer (A) is greater than about $-2\text{ }^\circ\text{C}$; and

(B) a copolymer comprised of the polymerization reaction product of an optional vinyl acetate or vinyl ether component, (C_{2-12}) alkyl (meth)acrylate, hydroxy(C_{1-5})alkyl(meth)acrylate, and optionally a polymerizable epoxy-containing monomer, said monomers being present in an amount such that the T_g of said copolymer (B) is less than about $-20\text{ }^\circ\text{C}$, and

wherein said copolymers (A) and (B) are present in said composition in a weight ratio ranging from about 0:100 to about 40:60.

There is also provided a method of damping vibrations or sound in an article comprising providing a film or layer of a vibration or sound damping material to the article such that said film or layer is capable of attenuating said vibration or sound in at least one vibrational or sound mode, the film or layer being comprised of the above composition.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

The adhesive composition of the present invention is comprised of low T_g copolymer (B) either alone or together high T_g polymer (A) and which may be used with particular advantage in vibration/sound-damping.

The composition of the present invention enables a number of benefits to be achieved. For instance, the composition enables highly desirable damping and absorption characteristics to be achieved over a wide frequency range (1Hz to 10 kHz). The tan delta of the composition (measured by Dynamic Mechanical Analysis) is an indication of energy loss and the composition of the invention enables values above 0.6 (at 1Hz), 1.2 (at 100 Hz), 2.1 (at 1kHz) and 3.0 (at 10kHz) to be achieved (thus confirming the ability of the composition to provide vibration/sound-damping).

Dynamic Mechanical Analysis (DMA) provides a useful tool to study the dynamic properties of a material and is often used to characterize the sound or vibration damping performance of polymers, particularly viscoelastic polymers. The tan delta of the material, as defined by the ratio of Loss Modulus (G) to Storage Modulus (G'), is a valuable indicator of the material's relative damping ability. Any peak in tan delta (particularly apparent in temperature profile studies) corresponds to a region where the material properties are changing rapidly; i.e., the material is undergoing a transition. In frequency dependent studies, a peak in tan delta indicates that the material dissipates the incident sound or vibration energy and converts to heat very well

at that frequency. High values of tan delta over a wide range of frequency is generally regarded as the platform for good broadband damping properties.

The composition of the present invention may be used with advantage in the electronics industry as the composition may be tailored to be ultra-clean by avoiding the presence of acid or polar components; i.e., the composition will preferably exhibit a leachable ion concentration below 22 ng/cm^2 , with outgassing as measured by Dynamic Headspace Analysis using GC-MS below 910 ng/cm^2 . Such values are within the parameters of the hard disk drive industry standards.

The demands on the electronics industry to increase memory capacity are driving the improvements in cleanliness levels. The development of MR (magnetoresistive) and GMR (giant magnetoresistivity) head technologies, with recording heads floating over the memory surface on a molecular layer of air, make trace amounts of VOC's (volatile organic compounds originating from the adhesive) operate as miniature "speed bumps" when they condense on the memory surface. This disrupts the reading and writing process, which is the essence of the electronic data storage and retrieval process.

The composition of the present invention also, due to its crosslinkable nature, may be crosslinked to exhibit inherent hardness, cold flow resistance, heat resistance, and broad band vibration attenuation. By way of example, a typical shear modulus (G') range measured by Dynamic Mechanical Analysis is $5 \times 10^5 \text{ dyne/cm}^2$ (at 1Hz), $2.1 \times 10^6 \text{ dyne/cm}^2$ (at 100 Hz), $6.2 \times 10^6 \text{ dyne/cm}^2$ (at 1 kHz) and $2.6 \times 10^7 \text{ dyne/cm}^2$ (at 10 kHz).

The composition of the present invention can be fine tuned to exhibit a range of adhesion, as desired.

The composition of the present invention may be used to damp vibrations or sound in an article by providing a film or layer of a vibration or sound damping material to the article comprised of the composition such that the film or layer is capable of attenuating vibration or sound in at least one vibrational or sound mode. For example, the composition may be coated on a surface of the article which surface is particularly related to the formation of vibrations or sound.

The high Tg copolymer (A) used in the composition of the present invention is comprised of the polymerization reaction product of an alkyl (meth)acrylate monomer having a Tg >20 °C., optionally a C₁₋₃₀ (meth)acrylate monomer, an optional nitrogen-containing polar monomer, and an optional epoxy-containing monomer, each as defined below. The monomers are present in an amount such that the Tg of the resulting polymer is greater than -2 °C..

The alkyl (meth)acrylate monomer having a Tg > 20 °C. may be selected from but not limited to the group consisting of t-butyl (meth)acrylate, hexadecyl acrylate, isobornyl (meth)acrylate, cyclododecyl acrylate, methyl methacrylate, secondary butyl methacrylate, ethyl methacrylate, cyclohexyl methacrylate and mixtures thereof.

The optional C₁₋₃₀ (meth)acrylate monomer used in the present invention may comprise a monomeric (meth)acrylic acid ester of a non-tertiary alcohol

wherein the alcohol portion has from 4 to 18 carbon atoms. Exemplary (meth)acrylate monomers include but are not limited to esters of (meth)acrylic acid with non-tertiary alcohols such as 1-butanol, 1-pentanol, 2-pentanol, 3-pentanol, 2-methyl-1-butanol, 1-methyl-pentanol, 2-methyl-1-pentanol, 3-methyl-1-pentanol, 2-ethyl-1-butanol, 3,5,5-trimethyl-1-hexanol, 3-heptanol, 2-octanol, 1-decanol, 1-dodecanol, etc.

Exemplary monomeric (meth)acrylate monomers having a carbon chain of at least 12 carbon atoms include but are not limited to lauryl acrylate (C₁₂), tridecylacrylate (C₁₃), myristyl acrylate (C₁₄), palmityl acrylate (C₁₆) and stearyl acrylate (C₁₈). Such monomers are well-known to those skilled in the art.

The at least one nitrogen-containing polar monomer may be selected from a wide range of suitable monomers. Such monomers include, for example, vinyl monomers having at least one nitrogen atom. Such monomers include but are not limited to N-mono-substituted acrylamides, such as a (meth)acrylamide, N-methylacrylamide, N-ethylacrylamide, N-methylolacrylamide, N-hydroxyethylacrylamide and diacetone acrylamide; N,N-disubstituted acrylamides such as N,N-dimethylacrylamide, N,N-diethylacrylamide, N-ethyl-N-aminoethylacrylamide, N-ethyl-N-hydroxyethylacrylamide, N,N-dimethylolacrylamide, and N,N-dihydroxyethylacrylamide, etc.

Exemplary nitrogen-containing monomers may also include but are not limited to N-vinyl lactam monomers such as N-vinyl-2-pyrrolidone, 5-methyl-

N-vinyl-2-pyrrolidone, 5-ethyl-N-vinyl-2-pyrrolidone, 3,3-dimethyl-N-vinyl-2-pyrrolidone, 3-methyl-N-vinyl-2-pyrrolidone, 3-ethyl-N-vinyl-2-pyrrolidone; 4-methyl-N-vinyl-2-pyrrolidone; 4-ethyl-N-vinyl-2-pyrrolidone; N-vinyl-2-valerolactam; N-vinyl-2-caprolactam; N-vinyl-2-piperidone; and N,N-dimethylacrylamide and mixtures of any of the foregoing. The corresponding allyl derivatives thereof are also suitable for use in the present invention. The noted lactams may also be substituted in the lactam ring by one or more lower alkyl groups having from 1 to 4 carbon atoms, with methyl, ethyl, or propyl groups being particularly preferred. The N-vinyl lactam monomer employed preferably comprises N-vinyl-2-pyrrolidone.

The polymerizable epoxy-containing monomer may be selected from a variety of vinyl-terminated epoxy-containing monomers. Exemplary polymerizable monomers include but are not limited to glycidyl esters of an α,β -ethylenically unsaturated carboxylic acid, such as (meth)acrylic or crotonic acid.

Exemplary glycidyl monomers for use in the present invention accordingly include but are not limited to glycidyl (meth)acrylate, glycidyl ethacrylate and glycidyl itaconate, acryl glycidyl ether, (meth)allyl glycidyl ether and 3,4-epoxy-1-vinylcyclohexane.

The alkyl (meth)acrylate monomer is present in the copolymerizable reactant mixture in an amount ranging from about 20 to 80 percent by weight, the polymerizable C_{1-30} (meth)acrylate monomer is present in the mixture in an amount ranging from about 0 to 50 percent by weight, the nitrogen-containing

polar monomer is present in the mixture in an amount ranging from about 0 to 50 percent by weight, and the polymerizable epoxy-containing monomer is present in the mixture in an amount ranging from about 0 to 50 percent by weight. The epoxy-containing monomer is preferably present in an amount greater than 15 percent by weight.

Other monomers in addition to the above monomers may be optionally included for reasons such as cost reduction, etc. For example, styrene and vinyl acetate may be incorporated into the copolymer with advantage. Such monomers, if present, will be employed in amounts such that the resulting copolymer will still have a Tg greater than 50 °C.

The alkyl (meth)acrylate monomer is present together with the nitrogen-containing monomer in an amount such that the resulting copolymer exhibits a Tg > 50 °C., and preferably at least 60 °C. Copolymer (A) does not inherently exhibit pressure sensitive adhesive properties. However, the polymer finds particular utility when blended with low Tg copolymer (B) to form a crosslinkable pressure sensitive adhesive composition.

Copolymer (B) a copolymer comprised of the polymerization reaction product of an optional vinyl acetate or vinyl ether component, C₍₂₋₁₂₎alkyl(meth)acrylate, hydroxy(C₁₋₅)alkyl(meth)acrylate, and an optional polymerizable epoxy-containing monomer (defined in the same manner as defined in connection with copolymer A). The monomers are present in an amount such that the Tg of said copolymer (B) is less than about -20 °C.

Exemplary hydroxy(C₁₋₅)alkyl(meth)acrylate monomers include but are not limited to hydroxyethyl(meth)acrylate, hydroxypropyl(meth)acrylate, hydroxybutyl(meth)acrylate, and corresponding dihydroxy compounds.

While a number of (C₂₋₁₂)alkyl(meth)acrylate monomers may be employed, the preferred monomer is 2-ethylhexylacrylate.

The vinyl acetate or vinyl ether component is present in copolymer (B) in an amount ranging from about 0 to about 30 percent by weight, the (C₂₋₁₂)alkyl(meth)acrylate component is present in said copolymer (B) in an amount ranging from about 70 to about 98 percent by weight, the hydroxy (C₁₋₅)alkyl(meth)acrylate component is present in an amount ranging from about 2 to about 20 percent by weight, and said polymerizable epoxy-containing monomer is present in an amount ranging from about 0 to about 5 percent by weight.

It may be particularly desirable to avoid the use of vinyl acetate in a composition which must meet ultra-clean standards to avoid the potential for the production of an acid component upon hydrolysis of the vinyl acetate upon contact with moisture in the ambient atmosphere.

Copolymers (A) and (B) are present in said composition in a weight ratio ranging from about 0:100 to about 60:40, and preferably in a weight ratio ranging from about 5:95 to about 40:60. The copolymers (A) and (B) may be blended together by any suitable means such as mechanical mixing using a propeller-type mixing blade.

Depending on the relative weight percentages of polymers (A) and (B), and the compatibility of the blend, the final blend may have two separate Tg values, or a single Tg value.

Copolymers (A) and (B) of the present invention can be prepared by any suitable reaction technique such as free radical initiation techniques in the presence of a solvent. Exemplary solvents include but are not limited to ethyl acetate, cyclohexane, ketones or mixtures thereof. Solids content during polymerization may typically range from about 40% to 60%. Exemplary free radical initiators include but are not limited to peresters, acyl peroxides and those of the azo type, such as 2,2'-azobis(isobutyronitrile), benzoyl peroxide, lauroyl peroxide, t-butyl perbenzoate, t-butyl peroxyvalate, dibenzyl peroxydicarbonate, and diisopropyl peroxydicarbonate. Ultraviolet light and ionizing radiation may also be employed. The free radical initiator is generally present in the reaction mixture in an amount ranging from 0.01 to 10 % by wt. based on the total weight of the monomers in the reaction mixture.

Typical polymerization temperatures range from 20 °C. to 150 °C. for periods of time of from 2 to 24 hours until the desired degree of conversion occurs. The resulting polymer will preferably exhibit a molecular weight in the range of 50,000 to 2,000,000.

Various polymer compositions are known in the art which comprise a glycidyl monomer and one or more of an acrylate and a nitrogen-containing monomer.

U.S. Patent No. 6,200,639 discloses at column 8, lines 25-36 a copolymer of glycidyl methacrylate and t-butyl methacrylate, optionally in association with an aromatic vinyl-functional monomer, one or more hydroxyl-functional (meth)acrylic monomers and one or more additional monomers.

U.S. Patent No. 5,723,191 discloses a tackified dual cure pressure sensitive adhesive comprised of a copolymer having an acrylic backbone, a glycidyl monomer, an unsaturated carboxylic acid monomer, and a vinyl lactam monomer, together with a tackifier.

U.S. Patent No. 3,787,380 discloses a copolymer of N-vinyl or N-allyl heterocyclic monomers; and unsaturated ester monomer and a glycidyl monomer.

U.S. Patent Nos. 4,812,541 and 5,639,811 disclose a pressure sensitive adhesive copolymer comprised of a N-vinyl lactam monomer, a glycidyl monomer and an alkyl (meth)acrylate monomer.

U.S. Patent No. 5,270,416 discloses a thermosetting powder comprised of a glycidyl monomer, a methyl (meth)acrylate, butyl acrylate and styrene.

U.S. Patent No. 3,857,905 discloses a thermosetting coating composition comprised of a glycidyl monomer, a lower alkyl acrylate and a methyl acrylate.

Various polymer compositions are also known in the art which are comprised of both high and low T_g polymer components. See, for example, U.S. Patent Nos. 3,846,368; 3,998,768; 4,107,235; 5,098,952; 5,098,956; and 5,827,609. U.S. Patent No. 5,827,609 discloses a multilayer pressure sensitive

adhesive construction where each layer exhibits a different glass transition temperature.

Any conventional solvent/diluent may be admixed with the copolymer blend to permit coating of the composition comprised of the blend of copolymers (A) and (B) at a sufficiently low viscosity. Exemplary solvents/diluents include but are not limited to xylene, toluene, butylacetate, acetone, methyl ethyl ketone, methyl isobutyl ketone, alcohols such as methanol, ethanol, propanol, butanol; ethylene glycol monomethyl ether, ethylene glycol monobutyl ether acetate, ethylene glycol monoethyl ether acetate, ethylene glycol monomethyl ether, ethylene glycol dibutyl ether; hexane, mineral spirits, and other aliphatic, cycloaliphatic or aromatic hydrocarbon solvents and other esters, ethers, ketones and alcohols, or mixtures thereof.

The resulting blend may be coated onto a backing material by any conventional manner, such as by roll coating, spray coating, or extrusion coating, etc. by use of conventional extrusion devices. The blend may be applied together with a solvent (typically having a solids content of about 30 percent by weight) and the solvent subsequently removed (such as by evaporation) to leave the tacky adhesive layer on the backing material (preferably having a solvent content of less than about 1 percent by weight). Typically, evaporation will occur at a temperature in the range of from about 150 °F to about 250 °F to ensure removal of any solvent as well as to permit crosslinking of the composition by thermocuring. Desirably, the coated

composition will have a thickness within the range of about 0.5 mil to about 50 mils.

Exemplary backing materials include but are not limited to flexible and inflexible backing materials conventionally employed in connection with pressure sensitive adhesives. Such materials include creped paper, kraft paper, fabrics (knits, non-wovens, wovens), foil and synthetic polymer films or sheets such as polyethylene, polypropylene, peel PMMA, polyvinyl chloride, polyamide, polyimide, poly(ethylene terephthalate), polycarbonate, and cellulose acetate, as well as glass, ceramics, metallized polymer films and other composite sheet materials.

The adhesive may be applied to one or both of the aforementioned backing materials, or sandwiched in alternating fashion between multiple layers of the aforementioned backing materials, to yield two sided tapes. Also, adhesives may be combined in discrete layers with or without benefit of a backing material.

In another embodiment, the adhesive may be applied between two release substrates or on a 2 side coated differential release substrate to form a transfer adhesive.

Various additional components may also be incorporated into the composition to modify the properties or characteristics thereof. A variety of fillers may be incorporated into the polymer blend to provide desired physical characteristics. For example, metallic flake filler such as stainless steel flake having a particle size of 25-75 microns and aspect ratios of 31-94 may be

incorporated into the composition in an amount of up to about 60 percent by weight to enhance vibration/sound-damping properties. Rigid polymers having a high Tg such as polymethylmethacrylate may be added to produce a controlled phase separation within the composition to further enhance vibration/sound-damping of the composition. A variety of conventional crosslinking compounds (such as blocked polyamines) may also be incorporated into the composition to enhance crosslinking of the composition.

The present invention is illustrated by the following Examples which are intended to be merely illustrative in nature and not limiting in scope.

EXAMPLE 1

A high Tg acrylic polymer (comprised of 40% by wt. t-butyl methacrylate, 10% by wt. butyl acrylate, 20% by wt. N-vinyl-2-pyrrolidone and 30% by wt. glycidyl methacrylate) was prepared in ethyl acetate solvent using a free radical initiator 1,1-di(t-amylperoxy)cyclohexane to a molecular weight of approximately 200,000 GPC relative to polystyrene and having a first glass transition temperature (Tg) of about 60°C (measured by DSC) and a second glass transition temperature (Tg) of above 90°C.

5.76 parts of a low Tg acrylic polymer synthesized (25% by wt. solids in ethyl acetate solvent) was mixed with 65.06 parts of a second copolymer (comprised of about 70% by wt. 2-ethylhexyl acrylate, about 20% by wt. vinyl acetate, 10% by wt. hydroxyethylacrylate and 0.2% by wt. glycidyl methacrylate, about 41% by wt. solids). 0.75 parts of Ancamine 2441 solution in the mixture of isopropanol and methylethylketone solvents was used in the

formulation. The resulting adhesive was coated on polyester film and dried for 3 minutes at 90°C and 3 minutes at 140°C to yield films of various thicknesses. Such films were colaminated to yield a thickness greater than 0.6 mm for Dynamic Mechanical Analysis (DMA). The DMA Master Curve for frequency ranging from 1 Hz to above 10 kHz was generated using a Rheometric Scientific RAA Dynamic Mechanical Analyzer with a parallel plate fixture. The Storage Modulus (G'), Loss Modulus (G'') and the tan delta at different frequency are summarized in Table 1 below:

Table 1

Dynamic mechanical analysis results

DMA Test Results	1 Hz	100 Hz	1 kHz	5 kHz
Storage Modulus (G'), Pa	3.38×10^4	1.20×10^5	3.07×10^5	5.95×10^7
Loss Modulus (G''), Pa	1.69×10^4	1.03×10^5	4.23×10^5	1.21×10^8
Tan delta	0.50	0.86	1.38	2.11

EXAMPLE 2

An adhesive blend comprised of 55.45 parts of a high Tg acrylic polymer (synthesized from 40% by wt. t-butyl methacrylate, 10% by wt. butyl acrylate, 20% by wt. N-vinyl-2-pyrrolidone and 30% by wt. glycidyl methacrylate) and 137.08 parts of a low Tg acrylic polymer (41% by wt. solids in ethyl acetate solvent of about 70% by wt. 2-ethylhexyl acrylate, about 20% by wt. vinyl acetate, 10% by wt. hydroxyethylacrylate and 0.2% by wt. glycidyl methacrylate) was prepared in the mixed solvent of ethyl acetate and toluene. A 5-mil pressure sensitive adhesive film was generated by coating the

blend on polyester film and subsequently removing the solvent using the following heating conditions: 5 minutes at 65.5°C, 5 minutes at 90°C and 5 minutes at 140°C. The DMA test results of Storage Modulus (G'), Loss Modulus (G'') and tan delta at 1 Hz, 100 Hz, 1 kHz and 10 kHz are summarized in Table 2 below:

Table 2
Dynamic mechanical analysis results

DMA Test Results	1 Hz	100 Hz	1 kHz	10 kHz
Storage Modulus (G'), Pa	8.15×10^4	3.03×10^5	2.37×10^6	2.37×10^7
Loss Modulus (G''), Pa	4.01×10^4	2.33×10^5	5.0341×10^6	1.21×10^8
Tan delta	0.49	0.77	2.14	2.11

The cleanliness of the pressure sensitive film was tested for leachable ions using the ion chromatography analysis. An adhesive sample of 50 cm² placed on aluminum foil was rinsed with 18 Meg-Ohm water and submerged in 20 mls of 18 Meg-Ohm water for extraction at 85°C for one hour. Following the extraction, the water was removed, filtered and tested for ionic cleanliness using a Waters 636 Ion Chromatograph. As shown in Table 3 below, the leachable ions are within the general acceptance criteria for Hard Disk Drive industry, indicating the ultra high cleanliness of the adhesive composition.

Table 3Summary of ionic chromatography test results

Species	MDL for Samples ($\mu\text{g}/\text{cm}^2$)	Test Results ($\mu\text{g}/\text{cm}^2$)	General Acceptance Criteria for Hard Disk Drive Industry ($\mu\text{g}/\text{cm}^2$)
Fluoride	0.0016	None Detected	0.05
Chloride	0.0080	<0.0080	0.05
Nitrite	0.0080	None Detected	0.05
Bromide	0.0080	None Detected	0.05
Nitrate	0.0080	None Detected	0.05
Phosphate	0.0080	None Detected	0.05
Sulfate	0.0080	None Detected	0.05
Lithium	0.0003	None Detected	NA
Sodium	0.0020	<0.0020	NA
Ammonium	0.0020	0.0092	0.10
Potassium	0.0032	None Detected	NA
Magnesium	0.0028	None Detected	NA
Calcium	0.0028	<0.0028	NA

The same pressure sensitive adhesive sample was tested for outgassing using Dynamic Headspace GC/MS and the test results are shown in Table 4 below:

Table 4Summary of Outgassing test results

	General Acceptance Criteria for Hard Disk Drive Industry (ng/cm^2)	Test Results (ng/cm^2)
Toluene	118	10.7
Pentanedione	93	None detected
2-Ethyl-hexanol	318	2.2
Benzoic acid	138	3.6
Octyl acetates	20	None detected
Octyl acrylates	225	None detected
Acrylic acids	81	None detected

Example 3

A high Tg acrylic polymer was synthesized in ethyl acetate solvent based on the monomers of 2-ethyl hexyl acrylate (54% by wt.), hydroxy ethyl acrylate (10% by wt.) and isobornyl methacrylate (36% by wt.), using free radical initiators 2,2'-azobis-(2-methylbutyronitrile) (Vazo 67) and 1,1'-azobis-1-cyclohexanecarbonitrile (Vazo 88). 115.8 parts of the synthesized acrylic polymer (about 53% solids in ethyl acetate) was blended with 223.1 parts of a second acrylic polymer of low Tg (about 41% by wt. solids in ethyl acetate solvent of about 70% by wt. 2-ethylhexyl acrylate, about 20% by wt. vinyl acetate, 10% by wt. hydroxyethylacrylate and 0.2% by wt. glycidyl methacrylate). The resulting adhesive was coated on polyester film and dried for 3 minutes at 90°C and 3 minutes at 140°C to generate films of various thicknesses. Such films were colaminated to give thickness greater than 0.6 mm for Dynamic Mechanical Analysis (DMA). The DMA Master Curve for frequency ranging from 1 Hz to above 10 kHz was generated using a Rheometric Scientific RAA Dynamic Mechanical Analyzer with a parallel plate fixture. The Storage Modulus (G'), Loss Modulus (G'') and tan delta at different frequency were shown in Table 5 below:

Table 5Dynamic mechanical analysis results

DMA Test Results	1 Hz	100 Hz	1 kHz	10 kHz
Storage Modulus (G'), Pa	6.41×10^5	3.37×10^6	7.79×10^6	3.56×10^7
Loss Modulus (G''), Pa	4.54×10^5	2.47×10^6	8.64×10^6	4.97×10^7
Tan delta	0.71	0.73	1.11	1.39

WHAT IS CLAIMED IS:

1. A pressure sensitive adhesive comprised of the following composition:

(A) a copolymer comprised of the polymerization reaction product of:

- (1) an alkyl (meth)acrylate monomer having a $T_g > 20$ °C.;
- (2) optionally a C_{1-30} (meth)acrylate monomer;
- (3) optionally a nitrogen-containing polar monomer; and
- (4) optionally a polymerizable epoxy-containing monomer,

said monomers being present in an amount such that the T_g of said copolymer (A) is greater than about -2 °C; and

(B) a copolymer comprised of the polymerization reaction product of:

- (1) optionally vinyl acetate or vinyl ether;
- (2) (C_{2-12}) alkyl(meth)acrylate;
- (3) hydroxy (C_{1-5}) alkyl(meth)acrylate; and
- (4) optionally a polymerizable epoxy-containing monomer,

said monomers being present in an amount such that the T_g of said copolymer (B) is less than about -20 °C, and

wherein said copolymers (A) and (B) are present in said composition in a weight ratio ranging from about 0:100 to about 60:40, preferably about 5:95 to about 60:40.

2. The composition of claim 1 wherein said nitrogen-containing monomer comprises an N-vinyl lactam monomers.

3. The composition of claim 2 wherein said an N-vinyl lactam monomer is selected from the group consisting of N-vinyl-2-pyrrolidone, 5-methyl-N-vinyl-2-pyrrolidone, 5-ethyl-N-vinyl-2-pyrrolidone, 3,3-dimethyl-N-vinyl-2-pyrrolidone, 3-methyl-N-vinyl-2-pyrrolidone, 3-ethyl-N-vinyl-2-pyrrolidone; 4-methyl-N-vinyl-2-pyrrolidone; 4-ethyl-N-vinyl-2-pyrrolidone; N-vinyl-2-valerolactam; N-vinyl-2-caprolactam; N-vinyl-2-piperidone; N,N-dimethylacrylamide and mixtures thereof.

4. The composition of claim 1 wherein said C₁₋₃₀ (meth)acrylate monomer is an ester of (meth)acrylic acid with a non-tertiary alcohol selected from the group consisting of 1-butanol, 1-pentanol, 2-pentanol, 3-pentanol, 2-methyl-1-butanol, 1-methyl-pentanol, 2-methyl-1-pentanol, 3-methyl-1-pentanol, 2-ethyl-1-butanol, 3,5,5-trimethyl-1-hexanol, 3-heptanol, 2-octanol, 1-decanol, 1-dodecanol and octadecanol.

5. The composition of claim 1 wherein said alkyl (meth)acrylate monomer having a T_g > 20 °C is selected from the group consisting of t-butyl (meth)acrylate, hexadecyl acrylate, isobornyl (meth)acrylate, cyclododecyl acrylate, methyl methacrylate, secondary butyl methacrylate, ethyl methacrylate, cyclohexyl methacrylate and mixtures thereof.

6. The composition of claim 1 wherein said epoxy resin comprises a glycidyl monomer.

7. The composition of claim 1 wherein the Tg of said copolymer (A) is at least -2 °C.

8. The composition of claim 1 wherein said alkyl (meth)acrylate is present in said copolymer (A) in an amount ranging from about 20 to 80 about percent by weight.

9. The composition of claim 1 wherein said C₁₋₃₀ (meth)acrylate monomer is present in said polymer in an amount ranging from 0 to about 50 percent by weight.

10. The composition of claim 1 wherein said epoxy-containing monomer is present in said copolymer (A) in an amount ranging from about 0 to about 50 percent by weight, based on the weight of copolymer (B).

11. The composition of claim 1 wherein said epoxy-containing monomer is present in said copolymer (B) in an amount ranging from about 0 to about 5 percent by weight, based on the weight of copolymer (B).

12. The composition of claim 1 wherein said nitrogen-containing monomer is present in said copolymer (A) in an amount ranging from about 0 to about 50 percent by weight.

13. The composition of claim 1, wherein said Tg of said copolymer (B) is below about -20 °C.

14. The composition of claim 1, wherein said vinyl acetate or vinyl ether is present in said copolymer (B) in an amount ranging from about 0 to about 30 percent by weight.

15. The composition of claim 1, wherein said hydroxy (C₁₋₅)alkyl(meth)acrylate is present in said copolymer (B) in an amount ranging from about 2 to about 20 percent by weight.

16. The composition of claim 1, wherein said (C₂₋₁₂)alkyl(meth)acrylate is present in said copolymer (B) in an amount ranging from about 70 to about 98 percent by weight.

17. The composition of claim 1, together with a backing material.

18. The composition of claim 1, in the form of a film.

19. A method of damping vibrations or sound in an article comprising providing a film or layer of a vibration or sound damping material to said article such that said film or layer is capable of attenuating said vibration or

sound in at least one vibrational or sound mode, said film or layer being comprised of a composition comprised of the following:

(A) a copolymer comprised of the polymerization reaction product of:

- (1) an alkyl (meth)acrylate monomer having a $T_g > 20$ °C.;
- (2) optionally a C_{1-30} (meth)acrylate monomer;
- (3) optionally a nitrogen-containing polar monomer; and
- (4) optionally a polymerizable epoxy-containing monomer,

said monomers being present in an amount such that the T_g of said copolymer (A) is greater than about -2 °C; and

(B) a copolymer comprised of the polymerization reaction product of:

- (1) optionally vinyl acetate or vinyl ether;
- (2) (C_{2-12}) alkyl(meth)acrylate;
- (3) hydroxy (C_{1-5}) alkyl(meth)acrylate; and
- (4) optionally a polymerizable epoxy-containing monomer,

said monomers being present in an amount such that the T_g of said copolymer (B) is less than about -20 °C, and

wherein said copolymers (A) and (B) are present in said composition in a weight ratio ranging from about 0:100 to about 60:40, preferably about 5:95 to about 60:40.

20. The method of claim 19, wherein said article comprises a disk drive in a computer system. .

21. The method of claim 19 wherein said composition is free of any

acid or polar monomers.

22. The method of claim 19 wherein said article comprises a part of an automobile.

23. The method of claim 19 wherein said article comprises a part of a home appliance.

24. The method of claim 19 wherein said film or layer is crosslinked.