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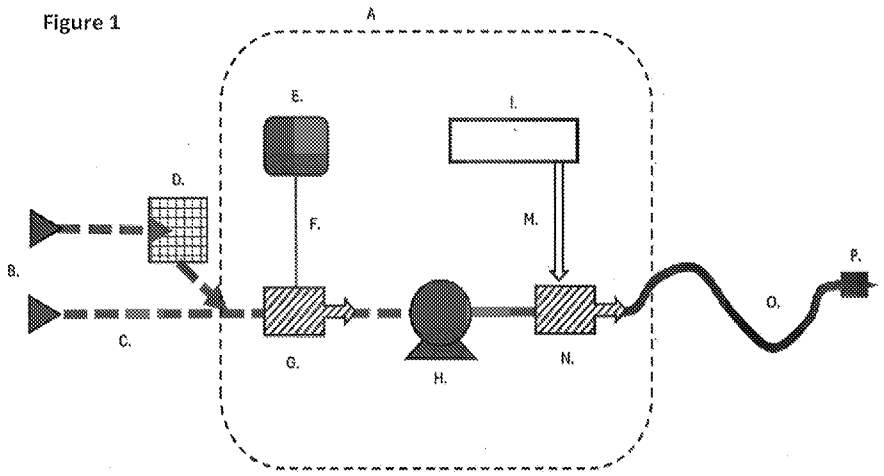
(54) Title: COMPOSITION, METHOD AND SYSTEM FOR PREVENTING OR MINIMISING RELEASE OF HARMFUL SUBSTANCES INTO THE ENVIRONMENT

Figure 1



(57) Abstract: The invention relates to a composition, method and system for preventing or minimising release of harmful substances into the environment. The invention particularly relates to facilitating safe removal and disposal of asbestos-containing materials and other hazardous materials, such as silica and silica-containing materials, and materials comprising friable particles or dust particles that have the potential to become airborne and be hazardous to health. A non-toxic biodegradable foamable composition is described which comprises a mixture of at least two plant-derived surfactants and at least one plant-derived foam stabilising agent, and which is formulated for use in a foam generation system wherein the composition is mixed with water at low pressure and compressed air at high pressure to generate a thick and stable foam. The foam is applied over and around contaminated materials thereby covering or encapsulating them to prevent the release of harmful airborne particles.

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— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
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Composition, Method and System for Preventing or Minimising Release of Harmful Substances into the Environment

Field of the Invention

The present invention relates generally to compositions, methods and systems for preventing or minimising release of harmful substances into the environment. The invention particularly relates to facilitating removal and disposal of hazardous materials from contaminated sites, for example, to compositions and methods for facilitating removal and disposal of asbestos and asbestos-containing materials and buildings or structures comprising same. The invention also has other applications, including treating other hazardous materials, such as silica and silica-containing materials, and materials comprising other friable particles or dust particles that have the potential to become airborne and be hazardous to health. It may also be useful for the treatment, removal and/or disposal of contaminated soil, and the treatment, removal and/or disposal of materials contaminated by carcinogens, mould, mould spores, pathogens, or by methamphetamine or other hazardous chemicals.

Background of Invention

Exposure to asbestos is recognized as a serious health hazard, which has caused many fatalities worldwide. Unfortunately, asbestos has been widely used in the past in building and construction, and in multiple other industries, due to its fire inhibiting, hydrophobic and strengthening qualities. Products containing asbestos were applied to structural building materials such as steel and plaster for fireproofing. Asbestos-containing materials were also used on ceilings and walls for thermal and acoustic insulation purposes, as well as for decorative purposes.

It is generally accepted that serious exposure problems can occur in buildings constructed with fireproofing, insulation and decorative materials made at least in part from asbestos, due to the decay, wear or disturbance of the materials. Asbestos-containing coatings, lagged

pipes, flock, sprayed fire insulation, linings and plastering materials are regarded as being particularly hazardous since they tend to become friable, and hence easily entrained into the air, as they deteriorate with age. The innate friability of asbestos is the cause of many health concerns and diseases resulting from the inhalation of airborne fibers.

There are many challenges involved in the safe removal and disposal of asbestos, particularly once the asbestos becomes friable and airborne. Asbestos fibers are not easily degraded or destroyed, and they tend to persist in the environment almost indefinitely. They can travel great distances and remain suspended in air for very long periods of time. Even settled asbestos fibers are easily stirred up by pedestrian traffic and the like and reintroduced back into the environment. Natural weather events and seismic activity can also exacerbate the problem by disturbing buildings that contain asbestos or asbestos-containing materials, which become exposed and friable because of damage.

Methods for dealing with the problem of asbestos contamination generally fall into two broad categories, being, encapsulation and removal. Encapsulation involves coating the asbestos-containing material with rubber-based sealants like Bostic ET150 which permit the asbestos-containing material to remain safely in place for longer periods of time than it otherwise could. However, at best, encapsulation is a temporary measure since sealants also will deteriorate with time. Furthermore, encapsulation methods are largely ineffective where the asbestos-containing material has undergone significant physical damage due to weather, seismic impacts, fire and/or aging. In such cases physical removal is the only safe alternative.

Asbestos removal procedures require that all asbestos-containing materials be taken off their underlying substrates, carefully collected and disposed of, preferably by burial or in carefully managed landfill. Asbestos removal is typically carried out using handheld impact and cutting tools and equipment within negative pressure enclosures to remove friable asbestos containing products and materials from a building substrate or surface using HEPA filtered vacuums. Some contaminated areas are so inaccessible that mechanical removal by scraping, chiseling, and scoring with simple hand tools remains the only option.

Unfortunately, during these removal operations, the asbestos-containing materials tend to pulverize upon impact or scraping, which results in heavy asbestos dust contamination. Work crews must be carefully protected against this, which typically involves the use of significant protective equipment (PPE/RPE) along with negative pressure enclosures to minimise any exposure to asbestos. However, even at low levels of exposure there is still a significant level of risk due to the friable nature of asbestos fibers.

Currently, the New Zealand Health & Safety at Work [Asbestos] Regulations 2016 and the related Asbestos Code of Practice outline the safe removal and disposal of asbestos requirements, which include the use of PPE/RPE, prescribed removal methods, and the double-bagging and gooseneck tying of contaminated waste and/or the wrapping of waste in double-lined 200-micron polythene which is taped. These are then transported and dumped at approved waste facilities. However, current practices are in many cases insufficient to ensure the safety of workers, and they are extremely expensive. For example, in demolition of unstable buildings containing asbestos, the crushing of asbestos insulation board (AIB), lagging, limpet and flock, concrete slabs and other structures containing asbestos rope, along with other high asbestos containing materials, the fiber release may exceed 1000 fibers per ml. Even when the site is enclosed and put in a negative pressure environment and when maximum PPE/RPE (such as positive pressure masks rated 3 fibers per ml) is used, the workers undertaking the demolition and removal are not sufficiently safe.

Further, once contaminated materials are disposed of, they are prone to becoming potentially airborne in the waste facility due to the physical offloading and handling of the dumped waste in the removal facility, and they will contaminate the landfills they are in. Even with safe work methods in place, the removal of asbestos remains extremely problematic, particularly in high-risk environments or sites with high concentrations of asbestos. Current asbestos removal practices in New Zealand are unable to eliminate the risk of asbestos exposure, and minimization of risk is questionable and poorly enforced.

To deal with dust contamination issues during physical asbestos removal operations, some "wet removal" processes have been developed. Wet removal generally involves wetting the contaminated material with water, using mist or fog cannons, to soften the material, and to

lower the friability of the asbestos-containing material and reduce the ability of the asbestos fibers to become airborne.

Unfortunately, water spraying is not a satisfactory solution to the problem since water penetrates slowly and does not completely saturate most building materials and tends to run off the treated surfaces. The water run-off creates obvious additional problems, such as water damage to the treated area, as well as potentially creating further contamination problems in another environment if asbestos fibers are carried in the water to other areas, dry out and become airborne again.

In other wet removal applications, aqueous solutions containing chemical surfactants have been used to attempt to improve water penetration into the asbestos-containing material. Surfactants that have been used for this purpose include polyethylene oxide condensates of alkyl phenols; the condensation products of aliphatic alcohols and ethylene oxide; the condensation products of ethylene oxide with a hydrophobic base formed by the condensation of propylene oxide with propylene glycol; condensation products of amines, amides or mercaptans with ethylene oxide or propylene oxide; products formed by reacting ethanolamine's with fatty acids; amine oxide surfactants; phosphine oxide surfactants and sulfoxide surfactants. However, these compositions have at least the same drawbacks as the use of water alone, and have the additional drawback of adding further toxic or hazardous chemicals into the environment.

Other wet removal compositions have been proposed to deal with water damage and run-off problems. For example, US Patent Number 4,347,150 describes a chemical formulation comprising a two-part wetting system, the first part being an aqueous alkali metal silicate dispersion blended with a cationic or nonionic surfactant and the second part comprising a mixture of an acrylic latex and a reagent that is reactive with the alkali metal silicates in the first part. The two parts are stored separately and are mixed shortly before use. Use of this type of formulation has a number of disadvantages, including: prohibitive cost due to the complex and expensive nature of the ingredients; time and agitation energy is required to affect the reaction of the two components; the resulting wet condition does not last for more than a few hours so the hazardous materials need to be continually resprayed in order to

prevent asbestos dust; the formulations tend to dry before they completely penetrate asbestos-containing materials so they do not cause complete separation of the asbestos-containing material from its substrate thereby creating dust from the remaining dry material; and further safety and environmental considerations given that some of the components of the formulation are themselves hazardous substances.

Another example of a chemical formulation for removing asbestos fiber containing building materials is described in US Patent Number 5,258,562, which involves application of a dilute aqueous solution of an acid, which may include a separate source of fluoride ions such as an alkali metal or ammonium salt of hydrofluoric acid to the building material for the purpose of conditioning the material to aid in its removal while partially converting the asbestos fibers. The building material, after having been treated with the dilute acid solution, is preferably removed for further treatment and/or discard.

A serious problem with the chemical compositions that have been used for facilitating asbestos removal and disposal is that they typically comprise hazardous chemical substances, such as strong acids and substantial volumes of solvents, that are either a further health and safety hazard to the workers using them, and/or are an environmental hazard because they are toxic and non-biodegradable.

Exposure to silica dust is also becoming a significant health hazard worldwide. Silica dust exposure is a problem in mining operations, in concrete cutting applications and in other industrial processes that generate silica dust. Furthermore, other harmful dust particles and mould and mould spores are often present in abandoned or deteriorated buildings that are no longer in use because of fire, natural disasters, or other events. Often these buildings are left in a state of instability for long periods of time with the result that harmful airborne particles are released into the air and environment as the buildings disintegrate over time.

Therefore, there is a need for improved compositions and methods for preventing or minimising release of harmful substances into the environment, including facilitating removal and disposal of asbestos and asbestos-containing materials, and other hazardous materials

such as silica dust and other harmful particles or pathogens that could become airborne, which are not only effective, but are also safe for workers and the environment.

Object of the Invention

It is an object of the invention to provide an improved composition and/or method and/or system for preventing or minimising release of harmful substances into the environment. It is a further object of the invention to provide an improved composition and/or method and/or system for facilitating removal and disposal of hazardous materials such as asbestos, asbestos-containing materials, silica, silica dust and other harmful particles or pathogens that have the potential to become airborne, that ameliorates some of the disadvantages and limitations of the known art; or that at least provides the public with a useful choice.

Summary of Invention

In a first aspect, the invention may broadly be said to consist in a foamable composition for preventing harmful substances from becoming airborne, wherein the foamable composition comprises a mixture of at least two plant-derived surfactants and at least one plant-derived foam stabilising agent, and wherein the foamable composition is formulated for use in a foam generation system wherein the composition is mixed with water and compressed air to generate a foam.

Preferably the foamable composition is used for facilitating demolition, removal and/or disposal of contaminated material comprising harmful or hazardous substances. More preferably, the foamable composition is used to facilitate demolition, removal and/or disposal of asbestos-containing materials, or silica containing materials, or buildings or structures comprising same. The foamable composition can also be used in soil remediation processes to treat contaminated soils.

Preferably, the plant-derived surfactants are selected from the group comprising triethanolamine laurel sulphate (also known as TEA-Lauryl sulphate and dodecyl sulfate

triethanolamine salt), sodium lauryl ether sulphate (also known as sodium laureth sulfate (SLES)), coco betaine (betaine), cocamidopropyl betaine (CAPB), lauramine oxide (also known as lauryldimethylamine oxide), and alkyl polyglucoside (APG), Coco glucoside, Decyl glucoside, Lauryl glucoside, Sucrose cocoate, Caprylyl/Capryl glucoside, Disodium Laureth Sulfosuccinate, sodium cocoyl glycinate, and Sodium coco sulfate, and derivatives thereof.

Preferably each plant-derived surfactant is present in the composition in an amount of from about 5 – 90% by weight.

More preferably, the triethanolamine laurel sulphate is present in an amount of at least 10% by weight. Preferably the sodium lauryl ether sulphate, and alkyl polyglucoside, if present in the composition, are present in an amount of from about 30 – 90% by weight.

More preferably, the cocamidopropyl betaine and lauramine oxide, if present in the composition, are present in an amount of from about 5 – 30% by weight. It has been found that these surfactants act synergistically with the other surfactants used, and therefore result in the production of a higher quality foam upon application. The particular combination and ratio of the surfactants will influence the degree of foaming and the stability of the foam.

Preferably, the plant-derived foam stabilising agent(s) are selected from the group comprising xanthan gum, cellulose gums such as carboxymethyl cellulose and ethyl cellulose, and vegetable gums such as guar gum and carrageenan, glycerol or glycerine, and proteins such as gelatin, and derivatives thereof.

Preferably, the or each plant-derived foam stabilising agent is present in the composition in an amount of from about 0.1 – 5% by weight.

In a preferred embodiment of the invention, the composition comprises (a) a combination of at least three plant-derived surfactants, including triethanolamine laurel sulphate in an amount in the range of about 10 – 20% by weight, sodium laurel ether sulphate in an amount in the range of about 50 – 80% by weight, and cocamidopropyl betaine in an amount in the

range of about 5 – 10% by weight, and (b) xanthan gum in an amount in the range of about 0.2 – 0.5% by weight.

Preferably the composition further comprises at least one preservative. The preservatives may be selected from the group comprising phenoxyethanol, isothiazolinones such as methylchloroisothiazolinone and methylisothiazolinone, and parabens such as methylparaben, ethylparaben, propylparaben and butylparaben.

Preferably, the preservative is present in the composition in an amount of 0.1 – 1% by weight.

The composition may also comprise water or an alternative diluent. In some embodiments of the invention a small amount of water is added to reduce the viscosity of the composition so that it can be applied more effectively via spray equipment.

The compositions of the invention may comprise additional optional ingredients, selected from the group comprising, dyes and coloring agents, suspending and thickening agents, binding agents, foam enhancing agents, humectants, emulsifying agents, pH adjustment agents, solvents, diluents, carriers, and additives or excipients that may attribute cohesive and/or adhesive properties to the resulting foam. In one embodiment of the invention, the composition may further comprise one or more foam enhancing agents such as lignin and/or cellulose to increase the stickiness and/or encapsulating properties of the foam. Such additives could be included in an amount of <10% by weight.

In one embodiment of the invention, the composition further comprises one or more adhesive agents, such as PVA (polyvinyl acetate) to improve the foam stability and/or adhesiveness. In this case the adhesive agent would be included in an amount of <10% by weight.

Preferably, the composition is a liquid composition in the form of a liquid foam concentrate. A liquid concentrate has the advantage of being easy to store, transport and handle, and is readily miscible with water.

Preferably the foamable composition forms a stable foam upon application in conjunction with water and compressed air.

Preferably, upon application, the foam will remain stable for at least 4 hours, but preferably up to 12 hours.

Preferably, upon application, the foam will have a thickness or a depth of at least 30 cm, but preferably at least 50 cm.

Preferably about 0.25 – 20% of the foam concentrate is mixed with water and compressed air prior to application. More preferably, about 1 – 10% of the foam concentrate is mixed with water and compressed air prior to application. Even more preferably, about 1 – 3% of the foam concentrate is mixed with water and compressed air prior to application. However, the ratio of foam concentrate to water and compressed air will depend on the purpose of application of the foam, namely what type of site or situation requires treatment.

In a further aspect, the invention may broadly be said to consist in a method for preventing harmful substances in a material from becoming airborne, wherein the method comprises applying a foamable composition comprising a mixture of at least two plant-derived surfactants and at least one plant-derived foam stabilising agent, in conjunction with water and compressed air, over and around the material to produce a layer or head of foam substantially covering or encapsulating the material.

Preferably the material is a contaminated material comprising harmful or hazardous substances such as asbestos-containing materials, silica containing materials, carcinogenic materials, mould or mould spores, pathogens, hazardous chemicals, harmful friable particles or dust particles.

In a further aspect, the invention may broadly be said to consist in a method of preventing or minimising the release of harmful airborne particles from a contaminated material, said method comprising the steps of:

(1) introducing a foamable composition comprising a mixture of at least two plant-derived surfactants and at least one plant-derived foam stabilising agent, into water to produce a foamable fluid;

(2) adding compressed air to the foamable fluid to generate a foam;

(3) applying the foam to the contaminated material.

Preferably the composition is introduced into the water at low pressure by injection into a water flow provided from a water supply. More preferably the water is introduced into the water flow by a venturi system.

Preferably, the compressed air is added by injection at high pressure, after the foamable fluid has passed through a high-pressure pump.

Preferably the method comprises repeated application of the foam during a decontamination process. Preferably the method further comprises the step of removing and disposing of the foam and contaminated material by mechanical means.

In a further aspect, the invention relates to a foam generation system for preventing harmful substances in a material from becoming airborne, wherein the system is configured for connection to a water source by a water supply hose or pipe, and the system comprises at least the following components:

(a) a housing or reservoir to hold a foamable composition;

(b) a means for introducing the foamable composition into the water supply hose or pipe at low pressure;

(c) a pump;

(d) an air supply source or an air compressor;

(e) a means for introducing air into the water supply hose or pipe at high pressure;

(f) a means to discharge a foam.

Preferably, the foamable composition comprises a mixture of at least two plant-derived surfactants and at least one plant-derived foam stabilising agent.

Preferably, the means for introducing the foamable composition into the water supply hose or pipe water is an injection means or a venturi system.

Preferably, the air compressor is a high-pressure screw air compressor.

Preferably, the means for introducing air into the water supply hose or pipe is by high-pressure injection.

Preferably, the means to discharge the foam is a distribution nozzle that is connected to an end of the water supply hose or pipe. The distribution nozzle may be connected to an additional lie flat or round hose that is connected to the water supply hose or pipe.

Preferably, the foam generation system is capable of generating a foam that remains stable for at least 4 hours after application.

Preferably, the foam generation system is capable of generating a foam that has a thickness or depth of at least 50 cm.

Preferably the foam generation system is readily transportable.

In a further aspect, the invention may broadly be said to consist in a method for safely demolishing a building or structure comprising contaminated materials, wherein said method comprises the steps of applying a foamable composition comprising a mixture of at least two plant-derived surfactants and at least one plant-derived foam stabilising agent, in conjunction with water and compressed air, over and/or around the building or structure to produce a layer or head of foam substantially covering or encapsulating the building or structure, and mechanically demolishing the building or structure beneath the foam.

Preferably the method comprises repeated application of the foam until the building or structure is fully demolished after which the foam and the demolished building or structure and contaminated materials are removed and disposed of.

In a further aspect, the invention may broadly be said to consist in a method for safely removing and disposing of contaminated soil, wherein said method comprises the steps of applying a foamable composition comprising a mixture of at least two plant-derived surfactants and at least one plant-derived foam stabilising agent, in conjunction with water and compressed air, over and/or around the soil to produce a layer or head of foam substantially covering or encapsulating the soil, and mechanically removing the soil beneath the foam.

Preferably the method comprises repeated application of the foam until the contaminated soil is removed.

Drawings

Figure 1 is a diagram illustrating the components of a preferred foam generation system of the invention.

Figure 2 is a photograph showing application of a foamable composition of the invention over a contaminated site.

Detailed Description

The invention relates to compositions and methods for preventing or minimising release of harmful substances into the environment. The invention particularly relates to facilitating removal and disposal of hazardous materials from a contaminated site, for example, to compositions and methods for facilitating removal and disposal of asbestos and asbestos-containing materials from buildings or structures comprising same. The invention may also have other suitable applications, including treating other hazardous materials, including silica and silica-containing materials, and materials comprising other friable particles or dust particles that have the potential to become airborne and cause damage to health. The invention is also useful for the treatment, removal and/or disposal of contaminated soil, soil burnouts, and the treatment, removal and/or disposal of materials contaminated by mould,

mould spores or pathogens, carcinogens, or methamphetamine or other hazardous chemicals.

The compositions of the invention are preferably liquid compositions in the form of a foam concentrate, or a foamable composition which forms a foam upon application in conjunction with water and compressed air. The foam essentially creates an "anti-friability" layer over the material comprising the hazardous substance(s) or particles, which prevents any hazardous substances or particles from becoming airborne during demolition, removal and/or disposal operations. By effectively covering or encapsulating the hazardous material(s) containing the particles, they are then non-respirable and safer to work with, and safer for the environment since they are contained and able to be better managed throughout the demolition, removal and/or disposal process.

An important feature of the compositions of the invention is that they are biodegradable and non-toxic. Therefore, they do not present an additional hazard to the health and safety of workers using them, nor does their use and application result in additional environmental concerns or cause further negative or hazardous impacts on the environment. Importantly, the foamable composition does not contain any harmful PFAS (perfluoroalkyl and polyfluoroalkyl) substances, or PFBS (perfluorobutane sulfonate).

The compositions of the invention comprise the following components: (a) a foaming system comprising at least two plant-derived surfactants, and (b) at least one plant-derived stabilising agent. The compositions of the invention are essentially a mixture or blend of at least these components which provides a foamable composition or a foam concentrate, that generates a stable foam when applied with water and compressed air.

The term, "plant-derived" as used herein broadly refers to substances that have been made or derived at least in part from plant material, including plant oils. The plant-derived substances used in the compositions of the invention are preferably food-grade, that is non-toxic and safe for consumption. At the very least, they are non-toxic or have low toxicity to human and/or animal health and are non-toxic or have low toxicity to the environment. The

plant-derived substances used in the compositions of the invention are also preferably biodegradable.

Some non-limiting examples of suitable plant-derived surfactants useable in the compositions of the invention include triethanolamine laurel sulphate (also known as TEA-Lauryl sulphate and dodecyl sulfate triethanolamine salt), sodium lauryl ether sulphate (also known as sodium laureth sulfate (SLES)), coco betaine (betaine), cocamidopropyl betaine (CAPB), lauramine oxide (also known as lauryldimethylamine oxide), and alkyl polyglucoside (APG), Coco glucoside, Decyl glucoside, Lauryl glucoside, Sucrose cocoate, Caprylyl/Capryl glucoside, Disodium Laureth Sulfosuccinate, sodium cocoyl glycinate, Sodium coco sulfate.

The above-listed plant-derived surfactants are generally commercially available, and sold under a variety of trade names by various manufacturers, however whatever their trade names their CAS numbers are:

Triethanolamine laurel sulphate 139-96-8;

Sodium lauryl ether sulphate 9004-82-4;

Cocamidopropyl betaine 61789-40-0;

Coco betaine 4292-10-8;

Lauramine oxide 1643-20-5;

Alkyl polyglucoside 68515-73-1;

Coco glucoside 1613372-14-7;

Decyl glucoside 54549-25-6;

Lauryl glucoside 59122-55-3;

Sucrose cocoate 91031-88-8;

Sodium cocoyl glycinate 90387-74-9;

Caprylyl/Capryl glucoside 68515-73-1;

Disodium Laureth Sulfosuccinate 39354-45-5, 40754-59-4, 42016-08-0, 58450-52-5, 68815-56-5;

Sodium coco sulfate 97375-27-4.

A person skilled in the art would appreciate that known derivatives or functional equivalents of these substances may also be used without deviating from the scope of the invention.

In preferred compositions of the invention, the foaming system of the composition comprises at least two plant-derived surfactants, but more preferably, the foaming system comprises three or more plant-derived surfactants. The type of surfactant selected is preferably a surfactant that has good foaming properties, but the formulations can be altered in response to issues such as cost and commercial availability of ingredients.

Each plant-derived surfactant is preferably present in the composition in an amount of about 5 – 90% by weight, depending on the type of surfactant used. For example, in compositions comprising triethanolamine laurel sulphate, the composition may typically comprise about 10 – 90% by weight of triethanolamine laurel sulphate. In compositions comprising sodium lauryl ether sulphate, the composition may typically comprise about 30 – 90% by weight of sodium lauryl ether sulphate. Similarly, in compositions comprising alkyl polyglucoside, the composition may typically comprise about 30 – 90% by weight of alkyl polyglucoside. In compositions comprising cocamidopropyl betaine, the composition may typically comprise about 5 – 30% by weight. Similarly, in compositions comprising lauramine oxide, the composition may typically comprise about 5 – 30% by weight. The combination of surfactants in the mixture creates a synergy that results in an enhanced foaming ability.

The compositions of the invention also comprise one or more plant-derived stabilising agent(s), which are included to assist in stabilising the resulting foam composition after the composition is applied to the hazardous substance(s) in conjunction with water and compressed air. It is important that the foam stays stable for as long as possible after application, so that the hazardous materials can be demolished, removed and/or disposed of with minimal risk of release of airborne particles.

Suitable plant-derived foam stabilising agents useable in the compositions of the invention include xanthan gum, cellulose gums such as carboxymethyl cellulose and ethyl cellulose, and vegetable gums such as guar gum and carrageenan, glycerol or glycerine, and proteins such as gelatin, and derivatives thereof.

In preferred embodiments of the invention, the plant-derived stabilising agent(s) are selected from the group comprising xanthan gum, cellulose gums such as carboxymethyl cellulose (CMC) and ethyl cellulose, and vegetable gums such as guar gum, carrageenan, glycerol or glycerine. These plant-derived stabilisers are generally commercially available and may be sold under a variety of trade names by various manufacturers, however their CAS numbers are:

Xanthan gum 11138-66-2;

Carboxymethyl cellulose 9004-32-4;

Ethyl cellulose 9004-57-3;

Guar gum 9000-3-0;

Carrageenan 9000-07-1;

Gelatin 9000-70-8.

A person skilled in the art would appreciate that known derivatives or functional equivalents of these substances may also be used without deviating from the scope of the invention.

Each plant-derived stabilising agent is preferably present in the composition in an amount of about 0.1 – 5% by weight.

The compositions of the invention may comprise one or more preservatives. Preferably these preservatives are food grade preservatives or are considered food grade when used in small amounts as described herein. In preferred embodiments of the invention, the preservatives may be selected from the group comprising phenoxyethanol, isothiazolinones such as methylchloroisothiazolinone and methylisothiazolinone, and parabens such as methylparaben, ethylparaben, propylparaben and butylparaben. Preferably, the preservative is present in the composition in an amount of about 0.1 – 1% by weight.

The composition may also comprise water or an alternative diluent. In some embodiments of the invention water is added to reduce the viscosity of the composition so that it can be applied more effectively via spray equipment. This is not essential however, as water could be added to the composition prior to or during application of the composition. Whether or not water or an alternative suitable diluent is added to the composition will depend on the

desired characteristics or properties of the composition for storage and transportation purposes, and the intended method of application of the composition.

The composition may comprise additional optional ingredients, such as carriers, additives and/or excipients to enhance the formulation or provide additional properties depending on the desired application. Some non-limiting examples include: dyes and coloring agents for coloring the foam to show the areas covered or to distinguish formulation variants of the foam; pH adjustment agents used to optimize foaming characteristics; and additives or excipients such as thickening and binding agents or foam enhancing agents that may attribute cohesive and/or adhesive properties to the resulting foam. Preferably, when selecting such optional ingredients, considerations are given to the potential toxicity of those ingredients, for example, ideally, safe ingredients are selected, such as plant-derived or food grade ingredients, or ingredients that are considered non-toxic or food grade when used in small amounts.

In one embodiment of the invention, the composition further comprises at least one adhesive substance, such as PVA (polyvinyl acetate) to improve the foam stability and adhesiveness. This embodiment of the foamable composition is particularly useful in situations where the site requiring treatment is not ready to be treated immediately, so application of a composition including PVA can be used as a first stage treatment to secure the site and prevent any release of harmful airborne particles during the waiting stage. Foam comprising a PVA additive will then be removed in a further stage when full treatment of the site is carried out with a non-PVA containing composition of the invention.

In another embodiment of the invention, the composition may further comprise one or more foam enhancing agents such as lignin and/or cellulose to increase the stickiness and/or encapsulating properties of the foam.

Any additional additives or excipients would be present in an amount of less than 10% by weight.

Methods of Preparation

The compositions of the invention can be made using methods known in the art. Typically, if all of the ingredients are liquid ingredients, they can be blended or mixed together using methods known in the art, however the order of addition of each ingredient may be important in order to avoid undesirable reactions such as an increase in viscosity. If one or more ingredients is not in liquid form, one or more suitable pre-treatment steps, such as dissolution or dispersion or solubilization steps, may be required, and will be known to persons skilled in the art. The preparation process of the compositions of the invention will depend on the final formulation of the composition, which may be varied to suit particular applications.

The compositions of the invention in liquid concentrate form are expected to be shelf-stable for up to five years.

EXAMPLES

This invention can be further understood by referring to the following illustrative examples in which percentages of the entire composition are by weight unless otherwise indicated. The following are representative of various possible formulations for general as well as specific use. Those skilled in the art will appreciate that the following compositions are offered by way of example only. They should not be considered as limiting this invention to any of the particular compositions exemplified.

Example 1

In one embodiment of the invention, the composition comprises (a) the following combination of plant-derived surfactants: triethanolamine laurel sulphate in an amount of 20% by weight, sodium laurel ether sulphate in an amount of <80% by weight, and cocamidopropyl betaine in an amount of 5% by weight, (b) xanthan gum as a stabiliser in an

amount of <0.5% by weight, (c) a preservative (phenoxyethanol) in an amount of <1% by weight, and (d) water to make up 100% by weight.

These ingredients are blended by methods known in the art to create a pumpable liquid. In this example, a small amount of water is added to the composition to reduce the viscosity of the composition so that it can be applied more effectively via the foam generation system. Preparation of the finished foamable formulation requires:

- Pre-treatment of the xanthan gum to enable it to be miscible in the other liquid ingredients without lumping.
- Addition of all ingredients to mix. The order of addition of the ingredients may be important to avoid undesirable reactions such as increase in viscosity.

Example 2

In another embodiment of the invention, the composition comprises (a) the following combination of plant-derived surfactants: triethanolamine laurel sulphate in an amount of <30% by weight, Lauramine oxide in an amount of <20% by weight, sodium laurel ether sulphate in an amount of <70% by weight, and cocamidopropyl betaine in an amount of 10% by weight, (b) xanthan gum in an amount of 0.2% by weight, (c) preservative (phenoxyethanol) in an amount of 0.4% by weight, and (d) water to make up 100% by weight. In this example, a small amount of water is added to the composition to reduce the viscosity of the composition so that it can be applied more effectively via the foam generation system.

These ingredients are blended to create a pumpable liquid. Preparation of the finished foaming formulation requires:

- Pre-treatment of the xanthan gum to enable it to be miscible in the other liquid ingredients without lumping.
- Addition of all ingredients to mix. The order of addition of the ingredients may be important to avoid undesirable reactions such as increase in viscosity.

Example 3

In a further preferred embodiment of the invention, the foamable composition comprises the following ingredients:

Ingredient	Amount (% by weight)
Glycerine or Glycerol	2.5
Sodium laurel ether sulphate	66
Water	16
Xanthan gum	0.5
TEA laurel sulphate	10
Cocamidopropyl betaine	5

In general, workable compositions of the invention have been made comprising various combinations of the following ingredients:

(A) At least two plant-derived surfactants such as:

Ingredient	Amount (% by weight)
Triethanolamine laurel sulphate	10 - 90
Sodium lauryl ether sulphate	30 – 90
Coco betaine	5 – 30
Lauramine oxide	5 – 30
Alkyl poly glucoside	30 - 90

(B) At least one plant-derived foam stabilising agent such as:

Ingredient	Amount (% by weight)
Xanthan gum	0.1 - 5
Carboxyl ethyl cellulose	0.1 – 5
Carboxyl methyl cellulose	0.1 – 5
Vegetable gum	0.1 - 5

(C) Optionally, a preservative in an amount of 0.1 – 1% by weight.

It is envisaged that ingredients that are derivatives of those listed above may also be used, or ingredients that are essentially functionally equivalent to the above ingredients in terms of their general chemical characteristics and properties.

The inventors have found that a surprisingly highly stable and very thick foam is generated when the compositions of the invention are applied in conjunction with water and compressed air. The foam has been found to be stable and to remain active for at least 4 hours and even up to 12 hours. This is extremely surprising and unexpected given that existing foams generally only remain stable for about 20 minutes. The foam is also surprisingly thick when applied, generally having a depth of between about 30 – 100 cm. It is thought that these properties of the resulting foam can be attributed to the particular synergistic combination of surfactants used, which provide a high degree of foaming and high stability of the resulting foam.

Method of Use

The invention provides an improved non-toxic and environmentally friendly process for removal of hazardous particulate matter having airborne potential. The process includes applying the foamable composition to the matter to be treated to prevent the particulate matter from becoming airborne. The foam effectively encapsulates and suppresses the particulate matter during demolition, removal and/or disposal processes, thereby preventing the escape of hazardous substances that are released and have potential to become airborne during these processes.

The compositions of the invention are liquid compositions, in the form of liquid concentrates, which are formulated to be applied in conjunction with water and compressed air to generate a foam. Preferably from about 0.25 – 20% of the foamable composition or foam concentrate is used in conjunction with water and compressed air. The ratio of the foamable composition or foam concentrate, water and compressed air will determine the wetness of the foam so the ratio can be altered to create the type of foam wetness required depending on the desired application. This forms a layer of foam which substantially covers and "encapsulates" the

hazardous materials to prevent them from becoming friable and airborne during demolition, removal and/or disposal operations. The inventors have found that the compositions of the invention surprisingly provide a very stable and thick layer of foam very quickly after application, generally within minutes of application. The foam has been found to remain active and stable for at least 4 hours, and preferably up to 12 hours after application. That is, the foam remains as a wet and stable foam continually moving and encapsulating the treated materials, including new surfaces and substrates of the materials as the materials are crushed or demolished or broken down during the operation.

The invention therefore provides a method of preventing or minimising the release of airborne particles from a contaminated material, said method comprising applying a composition of the invention, in conjunction with water and compressed air, over and around the material to form a layer or blanket of foam that substantially covers or encapsulates the material.

The method could be used for removing and disposing of a material comprising a hazardous substance, such as asbestos or silica. The method comprises the steps of applying a foamable composition as described herein, in conjunction with water and compressed air, over and around the material to form a layer or blanket substantially covering or encapsulating the material, and mechanically removing the foam and contaminated material for disposal.

Preferably, the application of the composition is carried out by equipment that is configured or adapted to introduce both water and compressed air to the foamable composition causing thorough mixing of the foamable composition with the water and compressed air to generate the foam and discharge the foam. Preferably compressed air is used, however other gases can be used if necessary, such as low molecular weight hydrocarbons, nitrogen, nitric oxide or carbon dioxide. Compressed air is preferred however due to the low cost, low toxicity, and the fact that a separate tank is not necessary.

Typically, the equipment required to generate and apply the foam will include the following components: (a) a housing for the foamable composition; (b) a housing for water, and/or means to connect to a water source; (c) a housing for compressed air or gas, and/or an air

compressor; (d) means to mix the foamable composition, water and air or gas to generate a foam; and (e) means to discharge the foam.

It is envisaged that the above components could be housed on a vehicle such as a truck, or a trailer or other transportable platform. For example, an adapted or modified fire fighting vehicle may be suitable.

Referring to **Figure 1**, a preferred foam generation system (A) is shown. The foam generation system is configured for connection with a water supply or water source (B) in use. The water supply may be provided by any water source, including water provided by public utilities, connection to a fire main or fire pump system, or water stored in separate vessels, or in water tanks that form part of the system. The system is connected to the water supply by a low-pressure water supply pipe (C). Preferably there are at least two lines of connection, that is, two pipes, one of which may optionally supply a water tank (D) which may form part of the system for storing excess water supplied to the system via the water supply. The foam generation system has a housing or reservoir (E) for containing a foamable composition, preferably a liquid foam concentrate. The reservoir (E) is connected to the system in a manner which enables the foamable composition to be introduced into the system at low pressure. This may be accomplished by a water injection system, or similar means known to persons skilled in the art. In the embodiment shown in Figure 1, the reservoir (E) is operably connected to the system via a tube or pipe (F) which introduces the water through a venturi system (G), preferably an adjustable dosing low pressure venturi injector. At that point the foamable composition is introduced into the water flowing through the water supply pipe (C) and begins mixing with the water. The mixed fluid then passes through a pump (H) which is operably connected to the water supply pipe and to a hose (O) having a discharge means (P) at the end. Preferably, the pump is a high-pressure liquid pump. The system further comprises an air compressor (I) which is operably connected to the water supply pipe (C) to introduce compressed air into the foam generation system. The air compressor (I) is preferably a high-pressure screw air compressor, but may be any suitable high-pressure air compressor known in the art. The air compressor provides an air supply for introducing compressed air into the fluid flow to aerate the mixed fluid and generate a foam. The compressed air is preferably introduced into the system via injection. In the embodiment

shown in Figure 1, the air compressor (I) is connected via a high-pressure hose or tube (M) to a high-pressure air injector or mixer (N) which is operably connected to the water supply pipe (C) and to the hose (O). The hose (O) feeds the foam to at least one discharge means (P) which is preferably in the form of a distribution nozzle that is configured to effectively distribute the foam over the area to be treated.

The hose (O) can be of any desired length to suit the application. For example, in some cases the hose (O) may be attached or installed along the length of a boom of a high reach excavator so that the discharge means (P) is situated about the excavator head to enable foam to be applied in high and/or inaccessible areas (for example through windows or ceilings of multi-storey buildings) before and during demolition processes.

The foam generation system as described has been found to produce an extremely high quality foam, with good foam structure, finer air bubbles or cells, and extremely high foam stability. The system provides for thorough mixing of the water, foamable composition and compressed air, so that a higher quality, stronger and longer lasting foam is generated. Injection of the compressed air at high pressure directly into the pre-mixed water and foamable composition in the water supply pipe creates sufficient turbulence to thoroughly mix the air into fluid to generate a foam with these excellent properties. In this way, high pressure air is combined with high pressure fluid flow containing the foamable composition, to fully aerate the composition. The air and water are pushed at high speed in the same direction towards the discharge means.

There are several advantages of the foam generation system described. First, due to the non-toxic and non-corrosive nature of the foamable composition, the foamable composition can be added to the system under low pressure before the pump. The composition does not cause damage or corrosion to the mechanical equipment including the supply lines and the pump. Prior art formulations comprising toxic or corrosive materials would cause a lot of damage to the mechanical equipment. Secondly, the composition does not clog the components of the system, and does not require regular flushing of the system to clean the equipment. Regular flushing of the system would be required if prior art formulations are used as the toxic and corrosive chemicals would need to be cleaned out regularly to prevent

damage and disintegration of the components of the system. Thirdly, the foam generation system does not require a high pressure foam injector to be used since the foamable composition can be added to the system under low pressure. The properties of the foamable composition allow it to be introduced into the system via a venturi system. The foamable composition can also be used with any type of hose or pipe, including flat hoses and round hoses.

Preferably the foam generation system is readily transportable, and convenient for field operations. For example, a fire fighting vehicle modified to include the above components is suitable. Alternatively, in certain situations, larger, more complex equipment may be required.

Ideally, the compositions of the invention are capable of generating a foam that is able to adhere to the material to be treated, no matter what its orientation is. For example, ideally the foam is able to adhere to building materials that are arranged horizontally, vertically, or on ceilings or inverted building structures, and maintain its integrity in these situations. In this regard, the compositions of the invention may contain additional additives or excipients which will assist with the cohesive and/or adhesive properties of the resulting foam. Ideally, the cohesive and adhesive properties of the foamable composition will enable the application of a relatively large quantity of foam in a relatively thick layer, in a single application, which will substantially cover and encapsulate the material to be treated for an extended period of time.

The method and system of the invention therefore enables contaminated areas to be sprayed with foam creating a covering or blanket over and around the area to be treated, that prevents particles from becoming airborne during subsequent demolition, removal and/or disposal operations. The application of the foam essentially "secures" the area to make it safe for workers and the surrounding environment.

The method and system of the invention is suitable for treating large areas or sites, such as large, damaged multi-storey buildings and surrounding areas that contain hazardous substances such as asbestos-containing materials. In these cases, the entire area is first

covered with foam by application of foam over and around the entire area to form a "blanket" over the area. It is possible to treat high and otherwise inaccessible areas by operably connecting the system to a high-reach excavator or other demolition equipment so that the foam can be distributed over the top of a tall building and/or through the windows of tall buildings. For example, the discharge hose and discharge means may be attached or installed along the length of a boom of an excavator so the foam can then be pumped up the boom and out through the discharge means attached to the grapple of the excavator.

Once the foam is applied, demolition can safely be carried out beneath the head of the foam, as the foam encapsulates the area and the substrates and surfaces and prevents the release of airborne particles during the demolition process. Preferably, foam is continuously applied during the demolition process to ensure continued encapsulation and prevention of the release of hazardous substances into the air. As the demolition process continues, the foam remains active and stable and maintains a continuous coating or "head" over the substrates and surfaces. The foam has the ability to move as the structure collapses and compresses, and the foam naturally continues to encapsulate newly exposed substrates and surfaces. As the building and structures break down, debris falls into the foam and the foam encapsulates the new debris.

A similar method can be used for soil remediation applications.

Further layers of foam can be applied during removal and disposal operations to avoid particles becoming airborne during transport and delivery, and subsequently in landfill. It should however be noted that the foam is unsuitable for use in negative pressure enclosures as the pressure of the compressed air may interfere with the negative pressure equipment.

It is envisaged that when transporting the removed contaminated material, a layer of foam could be applied to the base of the receptacle (for example a truck bed) before the removed hazardous material is loaded, and another layer could be applied on top of the material prior to it being sealed. It is also envisaged that the compositions of the invention could be used at landfills as a means to manage the risk of the contaminated material becoming airborne following disposal.

Field Testing

A foamable composition of the invention was trialed in the decontamination and remediation of a building and surrounding area that was destroyed by a landslide. The duration of the operation was six weeks from the date of the landslide to the date that clearance was given confirming successful decontamination and remediation of the site. The building and surrounding environment, including soil, had to be fully treated and it was a large area. The building was full of AIB (asbestos insulating board) so there was significant risk of exposure to airborne asbestos particles during the operation.

A specially adapted fire truck was used for the operation. The first step was the application of a first layer or blanket of foam to the entire exterior and interior of the damaged building and surrounding area before any demolition was carried out. After application of the foam, a hydraulic excavator was used to demolish the building, with foam being applied continuously during the demolition process. The depth of the foam was about 50 – 75 cm. Figure 2 is a photograph illustrating the depth of the foam during the operation, noting that the grapple on the excavator in the photograph is about 100 cm in length. The hydraulic excavator was able to continue to crush and demolish the building beneath the head of the foam. Additional foam was applied every evening prior to leaving the site, to ensure the materials remained fully encapsulated overnight. Demolition continued until the debris and foam was removed from site by trucks and disposed of in landfill.

The foam generation system used 100 cubic feet per minute of compressed air (via two lines), and approximately 1680 liters of water per hour (via two lines). These were mixed with about 1 – 3% of foam concentrate to generate the foam.

Asbestos monitors were placed all around the site in three layers, namely within 10 metres of the site; within 20 metres of the site and within 30 metres of the site. The asbestos monitors were programmed to take regular CAL readings which were monitored daily. The current safety standard for asbestos levels is <0.01 fibres/ml of air as an 8-hour time-weighted average. All of the readings throughout the operation came back under this level.

These results demonstrate that the composition and method of the invention was extremely effective in suppressing the release of asbestos fibers into the environment during the demolition and removal of the damaged building and surrounding soil. The workers were not exposed to harmful levels of asbestos at any time during the operation.

Other Applications

It is envisaged that the composition and method of the invention could be used for other purposes, not just for the safe removal and disposal of hazardous substances such as asbestos and silica dust. For example, the compositions of the invention could also be used as a means for suffocating sick or diseased animals quickly and humanely (for example, large numbers of chickens carrying the Avian flu or other harmful pathogens to prevent the pathogens from becoming airborne and spreading).

Advantages

The compositions and methods of the invention offer a number of potentially realisable advantages over the prior art, including:

- The compositions of the invention are safe, non-toxic, and readily biodegradable;
- The compositions do not contain any harmful PFAS ingredients.
- The compositions effectively reduce the likelihood of hazardous or harmful particles becoming airborne and therefore respirable during removal and disposal operations, resulting in decreased exposure to particles that can pose a significant health risk. This will not only benefit workers in the industry, but also owners of contaminated buildings and sites, the healthcare system, the environment, and the wider community;
- The compositions allow for reduced cost of treatment of contaminated sites as continuous application of foam enables work to be undertaken at a faster speed;
- Safer transportation of waste which benefits the wider community and prevents further contamination;

- Safer treatment of waste at approved waste facilities as the risk of particles becoming airborne again is reduced;
- It is envisaged that the compositions and method of the invention could be used across multiple industries including construction, demolition, asbestos removal, environmental decontamination, soil remediation as well as being used as an immediate solution following burnouts, earthquakes, flood damage, tsunamis and other natural disasters, as a way of minimizing harmful airborne materials following a disaster;
- The potential uses of the foam composition in other applications to reduce friability of hazardous or harmful or potentially hazardous or harmful materials are extensive.
- The compositions and method of the invention allows for significant reductions in water usage when dealing with dust or particle suppression and removal of hazardous substances. The system of the invention provides a 10 – 50% reduction in water usage, making it a lot more environmentally friendly than current methods, including traditional dust or particle suppression systems using mist or fog cannons.
- Due to the non-toxic and non-corrosive nature of the foamable composition, the composition does not damage application equipment, such as pumps and hoses.

At the very least, the present invention offers the public a useful choice.

Disclaimers

It will be understood that the above-described preferred embodiments of the invention have been given purely by way of illustrative example. They are not to be construed as in any way limiting the scope of the invention, and variations or modifications thereto are possible without departing from its scope. In particular, any specific dimensions or other characteristics related to the preferred embodiments disclosed herein are not to be construed as limiting.

It will be understood that all and any modifications or variations to the invention herein described that would be apparent to a person skilled in the art are deemed to fall within the broad scope and ambit of the present invention.

The invention may also broadly be said to consist in the parts, elements and features referred to or indicated herein, individually or collectively, and any or all combinations of any two or more of the parts, elements or features. Where specific integers are mentioned herein which have known equivalents, such equivalents are deemed to be incorporated herein as if individually set forth.

To avoid doubt, it will be understood that where a product, device, system, method or process as herein described is sold, offered for sale or otherwise provided incomplete, as an individual component, or as a "kit of parts", such exploitation is deemed to fall within the ambit of the present invention.

Throughout the present specification, reference to a "skilled person", "skilled addressee", or "person skilled in the art" should be understood as referring to a practitioner having ordinary skill in the relevant field, but implementing this in an unimaginative manner. It will be appreciated that a degree of trial and experimentation may fall within the ambit of the practice of the skilled addressee when performing the invention disclosed herein.

Throughout the present specification, any references to "comprise" and derivatives of that term are to be interpreted inclusively. That is to say, references to "comprise" will be taken to include not only any listed components directly referenced in a given case, but also other non-specified components or elements. This applies whether the term "comprise" is used in relation to a product, device, system, one or more steps in a method or process, or any other aspect of the invention herein disclosed. To avoid doubt, "comprise" is not to be ascribed an exclusive meaning; that is to say, it is not to be taken to exclude any features, components, integers or steps merely due to their not being explicitly mentioned.

Similarly, the terms "including and having" or "having and including", if used herein, are to be defined inclusively.

Throughout the present specification, the terms "upper", "up", "lower", "down", "right", "left", "vertical", "horizontal", "top", "bottom", "lateral", "longitudinal", "side", "front",

"rear" and derivatives thereof shall relate to the invention as it is oriented in the Figures, if any. However, it is to be understood that the invention may from time to time assume various alternative orientations, except where expressly specified to the contrary. In any given case, reference to the above-listed terms should be accorded the meaning reasonably indicated by the context.

All references cited in this specification, including any patent or patent application, or any document, act, or item of knowledge, are hereby incorporated by reference. The discussion of these references states what their authors (or proponents) assert. No admission is made that any reference constitutes valid prior art; neither is any admission made as to the accuracy or pertinency of any reference. All rights to challenge the accuracy, pertinency and/or validity as prior art of any reference are hereby reserved.

CLAIMS

1. A foamable composition for preventing harmful substances from becoming airborne, wherein the foamable composition comprises a mixture of at least two plant-derived surfactants and at least one plant-derived foam stabilising agent, and wherein the composition is formulated for use in a foam generation system whereby the foamable composition is mixed with a water supply at low pressure and a compressed air supply at high pressure to generate a foam.

2. The foamable composition as claimed in claim 1 wherein the plant-derived surfactants are selected from the group comprising triethanolamine laurel sulphate (also known as TEA-Lauryl sulphate and dodecyl sulfate triethanolamine salt), sodium lauryl ether sulphate (also known as sodium laureth sulfate (SLES)), coco betaine (betaine), cocamidopropyl betaine (CAPB), lauramine oxide (also known as lauryldimethylamine oxide), and alkyl polyglucoside (APG), Coco glucoside, Decyl glucoside, Lauryl glucoside, Sucrose cocoate, Caprylyl/Capryl glucoside, Disodium Laureth Sulfosuccinate, sodium cocoyl glycinate, and Sodium coco sulfate, and derivatives thereof.

3. The foamable composition of claim 2 wherein each plant-derived surfactant is present in the composition in an amount of from about 5 – 90% by weight, or from about 5 – 30% by weight, or from about 30 – 90% by weight.

4. The foamable composition of any one of the previous claims, wherein the plant-derived foam stabilising agent(s) are selected from the group comprising xanthan gum, cellulose gums such as carboxymethyl cellulose and ethyl cellulose, and vegetable gums such as guar gum and carrageenan, glycerol or glycerine, and proteins such as gelatin, and derivatives thereof.

5. The foamable composition of claim 4, wherein the or each plant-derived foam stabilising agent is present in the composition in an amount of from about 0.1 – 5% by weight.

6. The foamable composition as claimed in any one of the previous claims wherein the composition comprises (a) a combination of at least three plant-derived surfactants, including triethanolamine laurel sulphate in an amount in the range of about 10 – 20% by weight, sodium laurel ether sulphate in an amount in the range of about 50 – 80% by weight, and cocamidopropyl betaine in an amount in the range of about 5 – 10% by weight, and (b) xanthan gum in an amount in the range of about 0.2 – 0.5% by weight.

7. The foamable composition as claimed in any one of the previous claims wherein the composition further comprises at least one preservative in an amount of about 0.1 – 1% by weight selected from the group comprising phenoxyethanol, isothiazolinones such as methylchloroisothiazolinone and methylisothiazolinone, and parabens such as methylparaben, ethylparaben, propylparaben and butylparaben.

8. The foamable composition of any one of the previous claims wherein the foamable composition is capable of generating a foam that remains stable for at least 4 hours.

9. The foamable composition of any one of the previous claims wherein the foamable composition is capable of generating a foam layer having a thickness or depth of at least 50 cm.

10. A method for preventing harmful substances in a material from becoming airborne, wherein the method comprises applying a foamable composition as claimed in any one of claims 1 – 9, in conjunction with water and compressed air, over and around the material to produce a layer or head of foam substantially covering or encapsulating the material.

11. The method of claim 10 wherein the material is a contaminated material comprising asbestos, silica, carcinogenic materials, mould or mould spores, pathogens, hazardous chemicals, harmful friable particles or dust particles.

12. A method as claimed in claim 10 or 11 wherein the method comprises introducing the foamable composition into a water flow at low pressure to form a mixed fluid, passing the mixed fluid through a pump, and adding compressed air to the mixed fluid under high pressure to generate a foam.

13. A method as claimed in claim 12 wherein the foamable composition is introduced into the water flow by a venturi system or other injection means.

14. A method as claimed in claim 12 wherein the compressed air is added by injection after the fluid is passed through the pump and before it is discharged through an application nozzle.

15. A method as claimed in any one of claims 10 to 14, wherein the method is used to demolish and/or remove a building or structure comprising contaminated materials, or for removal and disposal of contaminated soil, and the method comprises repeated application of the foam to the building or structure or the soil, while demolition or removal is carried out beneath the head of the foam.

16. A foam generation system for preventing harmful substances in a material from becoming airborne, wherein the system is configured for connection to a water source by a water supply hose or pipe, and the system comprises at least the following components:

(a) a housing or reservoir to hold a foamable composition as claimed in any one of claims 1 – 9;

(b) a means for introducing the foamable composition into the water supply hose or pipe at low pressure;

(c) a pump;

(d) an air supply source or an air compressor;

(e) a means for introducing air into the water supply hose or pipe at high pressure to generate a foam;

(f) a means to discharge the foam.

17. A foam generation system as claimed in claim 16, wherein the means for introducing the foamable composition into the water supply hose or pipe is an injection apparatus or a venturi system.

18. A foam generation system as claimed in claim 16 or 17, wherein the means for introducing air into the water supply hose or pipe is a high-pressure injection apparatus.

19. A foam generation system as claimed in claim 16 or 17, wherein the system is capable of generating a foam that remains stable for at least 4 hours after application.

20. A foam generation system as claimed in any one of claims 16 to 18, wherein the system is capable of generating a foam that has a thickness or depth of at least 50 cm.

Figure 1

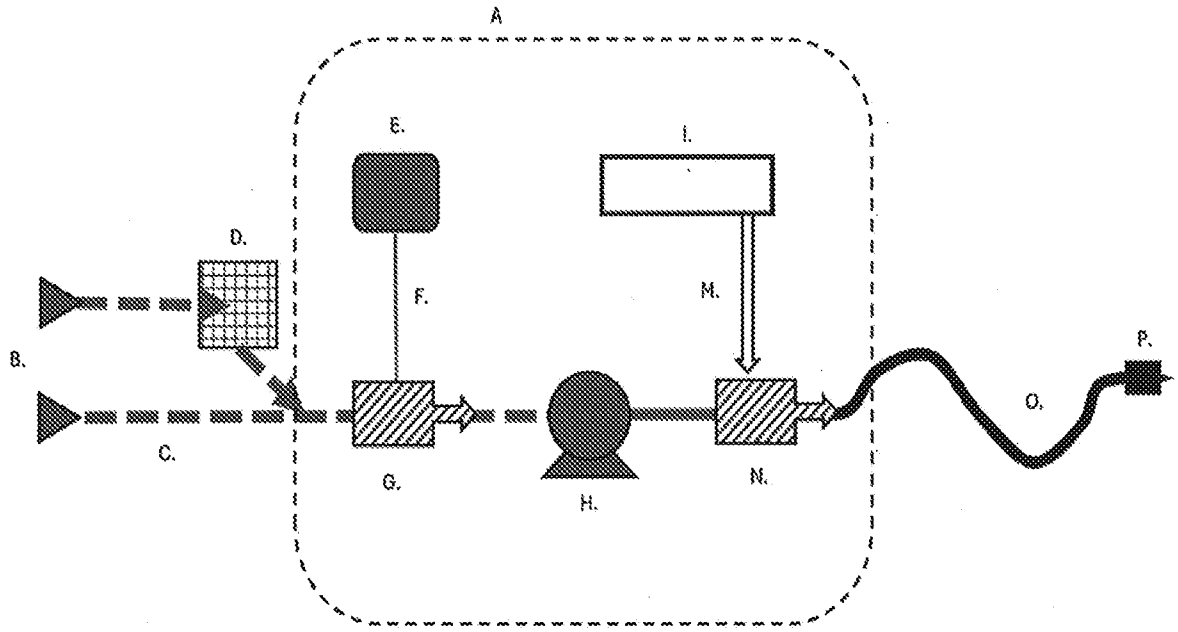
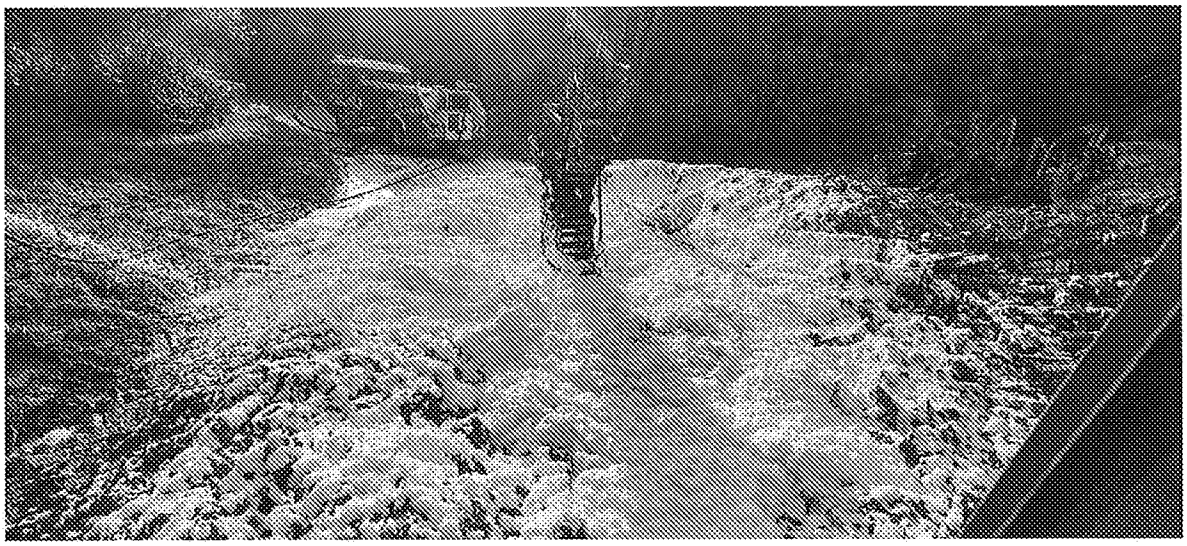


Figure 2



INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ2024/050056

A. CLASSIFICATION OF SUBJECT MATTER

C09K 23/00 (2022.01) ***B05B 7/00 (2006.01)*** ***B08B 3/00 (2006.01)*** ***B08B 7/00 (2006.01)*** ***B08B 15/00 (2006.01)***
B09B 3/00 (2022.01) ***B09B 101/35 (2022.01)*** ***C09K 23/02 (2022.01)*** ***C09K 23/16 (2022.01)*** ***C09K 23/28 (2022.01)***
C09K 23/56 (2022.01)

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

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

Databases: PATENW, REGISTRY, CAplus, CASFORM, INSPEC, MEDLINE, PQSCITECH
IPC/CPC Marks: A62D3/30/low, B05B, B08B3, B08B7, B08B15, B09B3, B09B101/35, B09B2101/35, C09K3/22, C09K23, C11D1
Keywords: lauryl sulfate, laureth sulfate, sodium olefin sulfonate, coco betaine, dodecyl amine oxide, lauryl dimethylamine, glucoside, ethanolamine sulfate, methyl cellulose, ethyl cellulose, propyl cellulose, carboxy cellulose, hydroxy cellulose, gum, natural, plant, biodegrade, asbestos, chrysotile, amosite, crocidolite, dust, airborne fibre, scatter, release, friable, prevent, seal, nullify, encapsulate, coat, decontaminate, tank, reservoir, housing, container, vessel, pump, hose, foam, air, water supply, high pressure, venturi and other like terms.
Applicant/Inventor: Google, CAplus and internal databases provided by IP Australia.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"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
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 August 2024	28 August 2024
Name and mailing address of the ISA/AU	**Authorised officer**
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au	Lloyd James AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. +61 2 6283 2335

INTERNATIONAL SEARCH REPORT C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		International application No. **PCT/NZ2024/050056**
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 20110018471 A (HWANG SUNG KWY et al.) 24 February 2011 Example, 'Spray Test' section and paragraphs [0010], [0016] & [0017]	1-20
X	CN 114133816 A (YUZHOU BOTAI MINE SAFETY SCIENCE AND TECH LIMITED COMPANY) 04 March 2022 Claims, Examples, paragraphs [0051]-[0063]	1-20
X	CN 110872485 A (UNIV NANTONG) 11 December 2019 Claims, Examples	1-20
X	US 10843154 B1 (NATIONAL TECHNOLOGY & ENGINEERING SOLUTIONS OF SANDIA) 24 November 2020 Table 1, column 1 lines 24-34	1-14 & 16-20
X	WO 2021243198 A1 (ISP INVESTMENTS LLC) 02 December 2021 Examples	1-9
X	US 5310508 A (SUBRAMANYAM et al) 10 May 1994 Example XXI	1-9
X	WO 2008135827 A1 (ECOLAB INC.) 13 November 2008 Page 1 line 22-page 2 line 14	16-20
X	KR 101887674 B (HWANG) 10 September 2018 Figures, paragraphs [0044]-[0055] & [0104]	16-20

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ2024/050056

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
the subject matter listed in Rule 39 on which, under Article 17(2)(a)(i), an international search is not required to be carried out, including

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Supplemental Box for Details

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Supplemental Box

Continuation of: **Box III**

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

This Authority has found that there are different inventions based on the following features that separate the claims into distinct groups:

- Claims 1 to 15 are directed to a foamable composition and methods utilising the same. The features of plant-derived surfactants and a plant-derived foam stabilising agent are specific to this group of claims.

- Claims 16 to 20 are directed to a foam generation system. The features of a housing or reservoir, a pump, an air supply, introduction means and discharge means are specific to this group of claims. Note that the housing or reservoir does not actually hold a foamable composition, but needs only to be suitable to hold such a composition.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

When there is no special technical feature common to all the claimed inventions there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claimed inventions and therefore cannot provide the required technical relationship. Therefore there is no special technical feature common to all the claimed inventions and the requirements for unity of invention are consequently not satisfied *a priori*.

It was considered that commenting on the second invention, insofar as it is supported by the specification, would not require significant additional effort. As such, no fees were invited.

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/NZ2024/050056**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
KR 20110018471 A	24 February 2011	KR 20110018471 A	24 Feb 2011
		KR 101128554 B1	23 Mar 2012
CN 114133816 A	04 March 2022	CN 114133816 A	04 Mar 2022
CN 110872485 A	11 December 2019	CN 110872485 A	10 Mar 2020
		CN 110872485 B	11 Mar 2022
US 10843154 B1	24 November 2020	US 10843154 B1	24 Nov 2020
WO 2021243198 A1	02 December 2021	WO 2021243198 A1	02 Dec 2021
		CN 116234894 A	06 Jun 2023
		EP 4157987 A1	05 Apr 2023
		US 2023193160 A1	22 Jun 2023
US 5310508 A	10 May 1994	US 5310508 A	10 May 1994
		AU 4166893 A	20 Jan 1994
		AU 662427 B2	31 Aug 1995
		BR 9302858 A	22 Feb 1994
		CA 2100372 A1	16 Jan 1994
		CN 1083095 A	02 Mar 1994
		EC SP930952 A	16 Nov 1994
		EP 0592073 A2	13 Apr 1994
		HU T66661 A	28 Dec 1994
		JP H06172156 A	21 Jun 1994
		KR 940005787 A	22 Mar 1994
		MA 22989 A1	01 Jul 1994
		MX 9304104 A	31 Mar 1994
		NZ 248094 A	21 Dec 1995
		PL 299654 A1	21 Mar 1994
		PL 173271 B1	27 Feb 1998
		RO 112366 B1	29 Aug 1997
		TR 28474 A	08 Aug 1996
		UY 23616 A1	05 Jan 1994
		ZA 934783 B	03 Jan 1995
		ZW 8693 A1	03 Nov 1993
WO 2008135827 A1	13 November 2008	None	
KR 101887674 B	10 September 2018	None	

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.