

RECOVERY OF TOBACCO CONSTITUENTS FROM PROCESSING

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This disclosure relates to, among other things, recovery of tobacco constituents or reaction products of constituents that are volatilized during processing of tobacco. The recovered constituents or reaction products can be added to compositions, such as aerosol-generating compositions for use in heated aerosol-generating smoking devices, to provide flavor or other desired attributes to the compositions.

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Electronic cigarettes (or "e-cigarettes") have been developed as an alternative to traditional cigarettes as a means for volatilizing active components, such as nicotine, for inhalation without combustion, while at the same time providing the user with an oral experience similar to that of traditional cigarette smoking. Many current e-cigarettes use a liquid (an "e-liquid") containing nicotine as the only component that is derived from tobacco. However, such e-liquids are often not capable of providing flavor or other sensory attributes of traditional smoking articles such as cigarettes. Accordingly, it may be desirable to include tobacco flavorants in e-liquids for use in e-cigarettes.

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Volatile tobacco constituents may be lost during processing of tobacco. For example, processing of tobacco to form expanded tobacco, such as dry ice expanded tobacco ("DIET"), can result in volatilization of tobacco-derived compounds that are rich in tobacco alkaloids. In such processes, the volatilized tobacco-derived compounds are typically carried in a waste gas stream and incinerated to produce energy for the tobacco expansion process. During such processes, some compounds can react to form reaction products that are also carried in the waste gas stream and incinerated. Some of these reaction products are produced via Maillard reactions between reducing sugars and tobacco alkaloids and contribute to the flavor of tobacco when it is being smoked.

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The tobacco alkaloids, reaction products, and other compounds produced or volatilized during a tobacco expansion process may be flavor compounds that can be used to add flavor, aroma, or other sensory attributes to compositions such as e-liquid compositions.

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In one aspect, there is provided a composition comprising nicotine and one or more tobacco-derived compounds, wherein the one or more tobacco-derived compounds are obtained by a process comprising condensing a gas stream employed in a tobacco expansion process comprising the tobacco-derived compounds to form a condensate, and fractionating the condensate to selectively recover or enrich the one or more tobacco-derived compounds.

In another aspect, there is provided an aerosol-generating composition for use in a heated aerosol-generating smoking device, comprising a composition described herein.

In another aspect, there is provided a method comprising: volatilizing one or more tobacco-derived compounds into a gas stream; recovering a composition comprising at least one of the one or more volatilized constituents or reaction products from the gas stream; and fractionating the composition to selectively recover or enrich at least one of the one or more volatilized constituents or reaction products.

In another aspect, there is provided a method for preparing an aerosol-generating composition for use in a heated aerosol-generating smoking article, comprising: formulating the composition described herein with one or more aqueous composition comprising nicotine, propylene glycol, glycerol or a combination of at least two of the foregoing substance.

One object of the present disclosure is to recover tobacco flavorants that are volatilized during tobacco processing. Such compounds are typically lost, or their content is reduced, with current tobacco processing methods. Another object is to provide compositions for use in heated aerosol-generating articles, which compositions include tobacco flavorants recovered during tobacco processing. The tobacco flavorants may provide flavor, aroma, or other sensory attributes to the compositions. Other objects of the present disclosure will be evident to those of skill in the art upon reading and understanding the present disclosure, which includes the claims that follow and accompanying drawings.

In one embodiment, the present disclosure provides a composition comprising nicotine and one or more tobacco flavorants, wherein the one or more

tobacco flavorants are obtained by condensing a gas stream comprising the one or more tobacco flavorants. The gas stream can be a gas stream employed in a tobacco expansion process. Preferably, the gas stream is a waste gas stream from a tobacco expansion process. In some embodiments, at least some, and preferably all, of the nicotine in the composition is also obtained by condensation of the gas stream. The compositions may be, or may form a portion of, an aerosol-generating composition for use in heated aerosol-generating smoking articles.

In another embodiment, the present disclosure provides a composition comprising nicotine, one or more tobacco flavorants, and at least one compound selected from the group of humectants, aerosol-forming agents, and other compounds of an aerosol-generating composition for use in a heated aerosol-generating smoking article, wherein the composition is produced by recovering at least some of the nicotine and the one or more tobacco flavorants by condensing a gas stream containing the nicotine and the one or more tobacco flavorants and formulating the condensate with at least one compound selected from the group of humectants, aerosol-forming agents, and other compounds of an aerosol-generating composition for use in a heated aerosol-generating smoking article.

As used herein, "formulating" means adjusting concentration of components, such as nicotine, flavorants and humectants, to levels that meet tobacco control regulations and produce an acceptable experience to adults when used in an aerosol-

generating device. Any composition described herein for use in an aerosol-generating device may be a formulated composition.

5 In various aspects of the present disclosure, a method is provided that includes volatilizing one or more tobacco-derived compounds into a gas stream and recovering at least one of the one or more volatilized tobacco-derived compounds from the gas stream by techniques well known in the art. Optionally, the method includes fractionating the recovered compounds by techniques well known in the art. Preferably at least one of the recovered tobacco-derived compounds is a tobacco flavorant. 10 Volatilizing the tobacco-derived compounds may be done by raising the temperature of the tobacco in a tobacco expansion process, such as but not limited to a dry ice expansion tobacco ("DIET") process.

In various aspects of the present disclosure, a method is provided for preparing an aerosol-generating composition for use in heated aerosol-generating device, that 15 includes recovering a tobacco flavorant from a gas stream, and adding the recovered tobacco flavorant to a composition including water and nicotine. The composition preferably includes polyethylene glycol, humectants or other suitable aerosol-forming agent.

In some aspects of the present disclosure, a method is provided for preparing an 20 aerosol-generating composition for use in a heated aerosol-generating device that includes recovering a tobacco flavorant and nicotine from a gas stream, and adding the recovered tobacco flavorant and nicotine to a composition including water. The composition preferably includes polyethylene glycol, humectants or other suitable aerosol-forming agent.

25 Various aspects of the methods and compositions of the present disclosure may have one or more advantages relative to currently available tobacco processing and processes for forming aerosol-generating compositions for use in heated aerosol-generating devices. For example, aspects of methods of the present disclosure recover tobacco flavorants, which may include key flavor compounds, during tobacco expansion 30 processes rather than losing or burning such compounds as done with current tobacco expansion processes. Additional advantages of one or more aspects of smoking articles, compositions or methods described herein will be evident to those of skill in the art upon reading and understanding the present disclosure.

The methods of the disclosure may be employed with any tobacco expansion process that results in volatilization of tobacco flavorants. As used herein, a “tobacco flavorant” is a tobacco-derived compound that produces an odor or flavor when smelled or tasted. A “tobacco-derived compound” is a compound naturally occurring in tobacco or a reaction product of naturally occurring tobacco compounds that may be generated during processing of tobacco. The tobacco-derived compounds, which may include tobacco flavorants, volatilized in a tobacco expansion process may be carried in a gas stream. Tobacco flavorants may be recovered from the gas stream and used to provide odor, aroma, flavor, or other sensory attributes to various compositions.

Volatilization of tobacco-derived compounds can result from raising the temperature of a composition comprising tobacco. However, volatilization can occur without heating, and volatilized compounds may be captured in accordance with the methods of the present invention. Volatilized tobacco-derived compounds may be captured and recovered from any suitable composition comprising tobacco constituents, such as dry tobacco compositions, tobacco suspensions, and the like. Preferably, volatilized tobacco-derived compounds are captured in a gas stream from which the compounds may be recovered. The volatilized compounds may be recovered in any suitable manner, such as by condensation, by affinity, and the like. One or more tobacco flavorants volatilized in the gas stream may be selectively recovered, enriched, or both selectively recovered and enriched in one or more steps.

In various embodiments, the methods of the disclosure include subjecting a composition comprising tobacco to conditions that result in volatilization of a tobacco-derived compound into a gas stream, and recovering the tobacco-derived compound from the gas stream. The conditions to which the tobacco composition is subjected, in part, determines whether a tobacco-derived compound will be volatilized. It will be understood that temperature, gas stream flow rate, and pressure can affect the amount of a tobacco-derived compound that is volatilized into the gas stream. The same factors can also affect the number of different compounds that are volatilized into the gas stream. The vapor pressure of a tobacco-derived compound also contributes to whether the tobacco-derived compound will be volatilized under a given set of conditions.

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Tobacco compositions that can be subjected to conditions in which tobacco-derived compounds are volatilized include dry tobacco compositions, suspensions containing tobacco, such as slurries, and the like. The term "tobacco" is used herein to indicate a *Nicotiana* species plant or one or more components of a *Nicotiana* species plant. The terms "tobacco" and "*Nicotiana* species" is used herein to indicate both a single species of *Nicotiana* and two or more species of *Nicotiana* forming a tobacco blend. "Tobacco" includes any component or subcomponent of a leaf, stem, stalk, flower, root, seed, or any other part of a *Nicotiana* species plant. Preferably, tobacco is tobacco cut filler. The term "tobacco cut filler" is used herein to indicate tobacco material that is predominately formed from the lamina portion of the tobacco leaf.

Tobacco compositions that can be subjected to conditions in which tobacco-derived compounds can be volatilized may include tobacco and a carrier. The carrier may be a solid, liquid or gas. If the carrier is a liquid, the composition may be a suspension. Examples of suitable liquid carriers for forming a suspension include water; ethanol; liquid carbon dioxide; Freon™ 11; ammonium carbonate; as well as supercritical fluids such as nitrogen, argon, helium, methane, propanol, pentane, and the like; or combinations of one or more of such liquid carriers. Preferably, the carrier impregnates the tobacco.

Examples of solid carriers include solid carbon dioxide, which is also known as dry ice. A preferred method to achieve a dry ice-tobacco composition is to contact the tobacco with liquid carbon dioxide under sufficiently high pressure to maintain the CO₂ in a liquid state and then to reduce pressure (such as to atmospheric pressure) to allow freezing of the CO₂, which occurs at about -78°C. Pressure sufficient to maintain the CO₂ in a liquid state, in some embodiments, is about 30 Bar (g). Preferably, the liquid CO₂ impregnates the tobacco. Preferably, the tobacco is submerged in the liquid CO₂ for an amount of time sufficient for the CO₂ to impregnate the tobacco, which may be from about 10 seconds to about 30 minutes, preferably about 15 minutes or less. Such impregnation is routinely carried out in DIET processes resulting in tobacco that is impregnated with non-gaseous carbon dioxide.

Preferably the temperature of a tobacco composition is increased and volatile constituents or reaction products are captured and carried in a gas stream. The tobacco composition may be heated at any suitable temperature. For example the

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tobacco composition may be heated at about 100°C to about 500°C; preferably at about 150°C to about 400°C; more preferably at about 180°C to about 300°C; even more preferably at about 220°C to about 290°C or at about 190°C to about 200°C. The tobacco composition may be contacted with a hot gas stream, where the hot gas is at a

5 temperature of 100°C to about 500°C; preferably about 150°C to about 400°C; more preferably about 180°C to about 300°C; even more preferably about 220°C to about 290°C or about 190°C to about 200°C.

It will be understood that the temperature and other conditions to which a tobacco composition is subjected can affect the ratio of tobacco constituent reaction

10 products to unreacted tobacco constituents. Accordingly, temperature and/or other conditions may be controlled to manipulate the ratio of unreacted to reacted constituents or the chemical composition of the resulting tobacco-derived compounds carried in a gas stream.

Examples of tobacco-derived compounds that can be carried in and recovered

15 from a tobacco processing gas stream include alkenes, alkanes, alcohols, esters, terpenes, alkaloids, ketones, naphthalines, cyclic ethers, ester alcohols, glycols, glycoethers, glycoesters, aldehydes, aromatic alcohols, cyclic aromatics, and the like. In some embodiments, tobacco-derived compounds include compounds resulting from Maillard reactions between reducing sugars and tobacco alkaloids. Some representative

20 examples of tobacco-derived compounds that can be recovered from a tobacco processing gas stream were identified by experiments and presented below in Table 1.

Table 1. Representative Examples of Tobacco-Derived Compounds and Classes that were detected in the tail gas stream of several DIET processes (S = previously found in smoke, T = previously found in tobacco; common names are provided in brackets)

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Name	CAS	Class
Hexane (S,T)	110-54-3	Alkane
Heptane (S)	142-82-5	Alkane
Octane (S,T)	111-65-9	Alkane

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Nonane (S,T)	111-84-2	Alkane
Decane (S,T)	124-18-5	Alkane
Undecane (S,T)	1120-21-4	Alkane
Dodecane (S,T)	112-40-3	Alkane
Tridecane (S,T)	629-50-5	Alkane
Tetradecane (S,T)	629-59-4	Alkane
Pentadecane (S,T)	629-62-9	Alkane
Hexadecane (S,T)	544-76-3	Alkane
Heptadecane (S,T)	629-78-7	Alkane
Octadecane (S,T)	593-45-3	Alkane
Nonadecan (S,T)	629-92-5	Alkane
Eicosane (S,T)	112-95-8	Alkane
2-methyl-pentane, (S,T)	107-83-5	Alkane
3-methyl-pentane (S,T)	96-14-0	Alkane
Methyl-cyclohexane (S,T)	96-37-7	Alkane
Cyclohexane (S)	110-82-7	Alkane
Hexane, 3-methyl- (S)	589-34-4	Alkane
Cyclohexane, methyl- (S)	108-87-2	Alkane
Heptane, 2,4-dimethyl- (T)	2213-23-2	Alkane

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1-Heptene (T)	592-76-7	Alkene
1-Octene (T)	111-66-0	Alkene
1-Nonene (T)	124-11-8	Alkene
1-Decene (S, T)	872-05-9	Alkene
1-Undecene (T)	821-95-4	Alkene
1-Dodecene (T)	112-41-4	Alkene
1-Tridecene (T)	2437-56-1	Alkene
Cyclohexene, 4-ethenyl- (S)	100-40-3	Alkene
Benzene (S,T)	71-43-2	Aromatic
Benzene, methyl- {toluene} (S,T)	108-88-3	Aromatic
Ethyl-benzene (S,T)	100-41-4	Aromatic
dimethyl-benzene (S,T)	1330-20-7	Aromatic
Benzene, 1,2-dimethyl- {o-xylene} (S,T)	95-47-6	Aromatic
Benzene, ethenyl- {styrene} (S, T)	100-42-5	Aromatic
Benzene, 1,3,5-trimethyl- {mesitylene} (S,T)	108-67-8	Aromatic
Benzene, 1,2,4-trimethyl- {pseudocumene} (S,T)	95-63-6	Aromatic
Benzene, 1,2,3-trimethyl- (S,T)	526-73-8	Aromatic
Benzene, (1-methylethyl)- {cumene} (S,T)	98-82-8	Aromatic

Propyl-benzene (S,T)	103-65-1	Aromatic
1-ethyl-3-methyl- Benzene, (S,T)	620-14-4	Aromatic
1-ethyl-4-methyl- Benzene, (S,T)	622-96-8	Aromatic
1-ethyl-2-methyl- Benzene, (S,T)	611-14-3	Aromatic
Benzene, 1-methyl-4-(1-methylethyl)- {p-cymene} (S,T)	99-87-6	Aromatic
1H-Indene, 2,3-dihydro- {indane} (S)	496-11-7	Aromatic
1,2,4,5-tetramethyl- Benzene, (S)	95-93-2	Aromatic
Naphthalene, 1,2,3,4-tetrahydro- {tetralin} (S,T)	119-64-2	Aromatic
Naphthalene (S,T)	91-20-3	Aromatic
Naphthalene, 2-methyl- (S,T)	91-57-6	Aromatic
Naphthalene, 1-methyl- (S,T)	90-12-0	Aromatic
Bicyclo[3.1.1]hept-2-ene, 2,6,6-trimethyl- { α -pinene} (S,T)	80-56-8	Terpenes
Bicyclo[3.1.1]heptane, 6,6-dimethyl-2-methylene- { β - pinene} (S,T)	127-91-3	Terpenes
Bicyclo[4.1.0]hept-3-ene, 3,7,7-trimethyl- (T)	13466-78-9	Terpenes
1,3-Cyclohexadiene, 1-methyl-4-(1-methylethyl)- { α - terpinene} (S,T)	99-86-5	Terpenes
Cyclohexene, 1-methyl-4-(1-methylethenyl)- {limonene; p-mentha-1,8-diene} (S,T)	138-86-3	Terpenes
2-Oxabicyclo[2.2.2]octane, 1,3,3-trimethyl- {eucalyptol; 1.8-cineole} (S,T)	470-82-6	Terpenes
1,6-Octadien-3-ol, 3,7-dimethyl- {linalool} (S,T)	78-70-6	Terpenes

Bicyclo[2.2.1]heptan-2-one, 1,7,7-trimethyl- {camphor} (T)	76-22-2	Terpenes
Bicyclo[2.2.1]heptan-2-ol, 1,7,7-trimethyl-, endo- {borneol} (S,T)	507-70-0	Terpenes
6-Octen-1-ol, 3,7-dimethyl- {dl-citronellol} (S,T)	106-22-9	Terpenes
1,4-Methanoazulene, decahydro-4,8,8-trimethyl-9- methylene-, [1S-(1 α ,3 α ,4 α ,8 α)]- (T)	475-20-7	Terpenes
Bicyclo[7.2.0]undec-4-ene, 4,11,11-trimethyl-8- methylene-, [1R-(1R*,4E,9S*)]- { β -caryophyllene} (T)	87-44-5	Terpenes
1-Propanol, 2-methyl- {isobutyl alcohol} (S,T)	78-83-1	Alcohols
1-Butanol {n-butyl alcohol} (S,T)	71-36-3	Alcohols
1-Hexanol, 2-ethyl- (S,T)	104-76-7	Alcohols
Benzenemethanol {benzyl alcohol} (S,T)	100-51-6	Alcohols
Acetic acid, methyl ester (S,T)	79-20-9	Esters
Acetic acid, ethenyl ester {vinyl acetate} (S)	108-05-4	Esters
Acetic acid, ethyl ester {ethyl acetate} (S,T)	141-78-6	Esters
Acetic acid, 1-methylethyl ester (S,T)	108-21-4	Esters
2-Propenoic acid, 2-methyl-, methyl ester (T)	80-62-6	Esters
Acetic acid, propyl ester {propyl acetate} (T)	109-60-4	Esters
Acetic acid, 2-methylpropyl ester {isobutyl acetate} (T)	110-19-0	Esters
Acetic acid, butyl ester {butyl acetate} (S,T)	123-86-4	Esters
Benzoic acid, methyl ester {methyl benzoate} (S,T)	93-58-3	Esters

Acetic acid, endo-1,7,7-trimethylbicyclo[2,2,1]heptan-2-yl ester {bornyl acetate} (T)	76-49-3	Esters
Benzoic acid, phenylmethyl ester {benzyl benzoate} (S, T)	120-51-4	Esters
2-Butanone {methyl ethyl ketone} (S,T)	78-93-3	Ketones
2-Pentanone, 4-methyl- (S,T)	108-10-1	Ketones
Cyclohexanone (S)	108-94-1	Ketones
3-Heptanone {ethyl butyl ketone} (S)	106-35-4	Ketones
4-Heptanone, 2,6-dimethyl- (S)	108-83-8	Ketones
Ethanone, 1-phenyl- {acetophenone} (S,T)	98-86-2	Ketones
Methanone, diphenyl- {benzophenone} (S,T)	119-61-9	Ketones
Furan, 2-methyl- (S,T)	534-22-5	Cyclic Ethers
Furan, tetrahydro- (S,T)	109-99-9	Cyclic Ethers
Ethanol, 2-methoxy- (S,T)	109-86-4	Glycol Esters
2-Propanol, 1-methoxy- (PGMM) (T)	107-98-2	Glycol Esters
1,2-Ethanediol {ethylene glycol} (S,T)	107-21-1	Glycol Esters
Ethanol, 2-ethoxy- (S,T)	110-80-5	Glycol Esters
2,4-Pentanediol, 2-methyl- (S,T)	107-41-5	Glycol Esters

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1,2-Propanediol {propylene glycol} (PG) (S,T)	57-55-6	Glycols
Ethanol, 2-phenoxy- (T)	122-99-6	Glycols, Glycolether
Butanal {butyraldehyde} (S,T)	123-72-8	Aldehydes
Pentanal {valeraldehyde} (S,T)	110-62-3	Aldehydes
Hexanal {caproic aldehyde} (S,T)	66-25-1	Aldehydes
Heptanal (S)	111-71-7	Aldehydes
Octanal (S,T)	124-13-0	Aldehydes
Nonanal {pelargonaldehyde} (S,T)	124-19-6	Aldehydes
Decanal {capraldehyde} (S,T)	112-31-2	Aldehydes
Undecanal (T)	112-44-7	Aldehydes
Benzaldehyde (S,T)	100-52-7	Aldehydes
2-Furancarboxaldehyde {furfural; 2-furaldehyde} (S,T)	98-01-1	Aldehydes
Tetradecanoic acid, 1-methylethyl ester (T)	110-27-0	fatty acid ester
Benzothiazole {benzosulfonazole} (S,T)	95-16-9	Heterocycle

2-Pyrrolidinone, 1-methyl- (S,T)	872-50-4	Heterocycle
Pyridine, 3-(1-methyl-2-pyrrolidinyl)-, (S)- {l-nicotine} (S, T) BP: 244.4°C	54-11-5	nicotine
Pyridine, 3-(3,4-dihydro-2H-pyrrol-5-yl)- {l-myosmine} (S,T) BP: 244.7°C	532-12-7	nicotine-related
Pyridine, 3-(1-methyl-1H-pyrrol-2-yl)- {nicotyrine} (S,T) BP: 282.8°C	487-19-4	nicotine-related
2-Pyrrolidinone, 1-methyl-5-(3-pyridinyl)-, (S)- {cotinine} (S, T) BP: 316°C	486-56-6	nicotine-related
3-Pyridinecarbonitrile {3-Cyanopyridine} (S,T) BP : 201°C	100-54-9	nicotine-related
Pyrazine, methyl- = Pyrazine, 2-methyl (S, T) BP: 135.1°C	109-08-0	Maillard reaction
Pyrazine, ethyl- = Pyrazine, 2-ethyl- (S, T) BP: 154.9°C	13925-00-3	Maillard reaction
Pyrazine, 2,3-dimethyl- (S, T) BP: 158.1°C	5910-89-4	Maillard reaction
Pyrazine, 2-ethyl-6-methyl- = Pyrazine, 6-ethyl-2-methyl- (S, T) BP: 170.2°C	13925-03-6	Maillard reaction
Pyrazine, trimethyl- (S, T) BP: 171-172 °C	14667-55-1	Maillard reaction

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Pyrazine, 2-ethyl-5-methyl- (S, T) BP: 168-170°C	13360-64-0	Maillard reaction
Pyrazine, dimethylethyl- (S,T) BP: 191.0 °C	71607-73-3	Maillard reaction

BP = Boiling point at 760 mmHg

In some preferred embodiments, one or more of the following tobacco-derived terpenes is captured in, and recovered together or separately from, a gas stream: α -pinene, β -pinene, α -terpinene, limonene, eucalyptol, linalool, camphor, borneol, citronellol and β -caryophyllene.

In some preferred embodiments, one or more of the following tobacco alkaloids is captured in and recovered together or separately from a gas stream: l-nicotine, l-myosmine, nicotyrine, cotinine, and 3-cyanopyridine.

In some preferred embodiments, one or more of the following tobacco-derived pyrazines, which are Maillard reaction products is captured in and recovered together or separately from a gas stream: 2-methyl-pyrazine, 2-ethyl-pyrazine, 2,3-dimethyl-pyrazine, 6-ethyl-2-methyl-pyrazine, trimethyl-pyrazine, 2-ethyl-5-methyl-pyrazine, and dimethylethyl-pyrazine. The tobacco-derived pyrazines are alkyl-substituted pyrazines, or alkylpyrazines. Examples of the alkyl group(s) include one or more methyl or ethyl groups, typically having boiling points in the range of 135°C to 191°C.

In some preferred embodiments, the recovered tobacco-derived compounds comprise one or more terpenes, nicotine and one or more pyrazines.

In some preferred embodiments, a recovered tobacco-derived compound includes a terpene, a tobacco alkaloid, or an alkylpyrazines. Tobacco alkaloids are well known in the art and include nicotine and its derivatives which include many heterocyclic derivatives of pyridine; the heterocyclic group can be, for example, a pyrrolidinyl group. Examples of tobacco alkaloids include l-nicotine, l-myosmine, nicotyrine, cotinine, and 3-cyanopyridine.

Any suitable gas may be used to carry volatile tobacco compounds to a suitable recovery apparatus. Examples of suitable gases for use in a gas stream include air, CO₂, O₂, inert gas such as N₂, steam or combinations of one or more of air, CO₂, O₂,

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inert gas such as N₂, and steam. Preferably, the gas stream comprises steam. The gas may comprise steam and an inert gas, steam and air, or the like. Preferably, the steam concentration of the gas stream is in the range of about 70% to about 95%; more preferably about 80% to about 90%; more preferably from about 82% to about 85%.

5 In many embodiments, the process plant is being operated continuously, and thus the gas stream may have any suitable speed as it is transported within the conduits of the process plants. Preferably, the speed of the gas stream is in the range from about 10 meters per second (m/s) to about 100 m/s; more preferably from about 20 m/s to about 50 m/s; even more preferably from about 30 m/s to about 40 m/s. Preferably,
10 the gas stream delivered at such speeds is a stream comprising steam.

Preferably, the methods of the present invention recover tobacco flavorants from a tobacco expansion process. Tobacco expansion processes include converting solid or liquid phase components into gas phase within a plant cell, thereby resulting in expanded tobacco. Tobacco expansion methods according to the present invention
15 include impregnating tobacco with a solid or liquid carrier, such as a carrier described above, and heating to cause expansion. Heating may be accomplished by placing impregnated tobacco in a hot gas stream, such as a gas stream described above. Tobacco-derived compounds carried in the gas stream can be directed to recovery apparatus, where tobacco flavorants can be recovered.

20 One preferred tobacco expansion process is a dry ice expanded tobacco ("DIET") process. DIET processes include impregnating tobacco with carbon dioxide under pressure and solidifying the carbon dioxide. The dry ice impregnated tobacco is introduced into a heated process gas which results in rapid expansion of the carbon dioxide or hydrates of carbon dioxide, such as CO₂·6H₂O, and thus rapid expansion of
25 the tobacco. The heated process gas can flow at any suitable velocity, such as in a range from about 10 meters/second to about 50 meters/second or other ranges as described above. The process gas may be at any suitable temperature, such as in a range from about 180°C to about 300°C or other ranges as described above. Any suitable process gas may be used, such as a gas comprising steam as described
30 above. In a typical DIET process, waste gas is fed through an incinerator where tobacco-derived compounds in the waste gas stream are incinerated. By way of example, DIET processes can result in losses from the tobacco of reducing sugars in

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the range from about 5% to about 8% and result in losses of total alkaloids in the range from about 15% to greater than 20%. According to embodiments of the methods described herein, tobacco-derived compounds are recovered before the waste gas is passed through an incinerator. This can be accomplished by redirecting a waste gas stream from the main process gas stream to recovery apparatus.

One preferred DIET process that may be employed or modified in accordance with the teachings presented herein is the AIRCO DIET process. Additional information on the AIRCO DIET process, plants and equipment can be found at the AIRCODIET website ([aircodiet.com](http://www.aircodiet.com)). More particular information regarding the AIRCO DIET process can be found in the AIRCO DIET publication, entitled "Dry Ice Expanded Tobacco" available at http://www.aircodiet.com/images/AIRCO_DIET_Process_Description.pdf, which is hereby incorporated herein in its entirety by reference to the extent that it does not conflict with the disclosure presented herein.

Tobacco-derived compounds may be recovered from a gas stream in any suitable manner. Non-limiting examples of suitable recovery mechanisms include condensation such as cryogenic condensation, rotary condensation, various chromatographic separations such as affinity chromatography, ion-exchange chromatography or size exclusion chromatography, reverse osmosis, solvent extraction, and the like. Aroma recovery techniques employed in the coffee industry can generally be applied to recovery of tobacco-derived compounds. Examples of such techniques include steam stripping, supercritical CO₂ extraction, pervaporation, and the like.

Preferably, tobacco-derived compounds are recovered from a gas stream, such as a re-directed waste gas stream, by condensation to form a liquid mixture, suspension, solution, or the like. Any suitable condenser may be employed. Typically a condenser is operated at a temperature of about 10°C or less, preferably about 5°C, to condense water carried in the gas. The water may be derived from the tobacco composition, the gas stream, or both the tobacco composition and the gas stream. The condensed water may include tobacco-derived compounds. The de-watered inert gas that has been passed through the condenser may be fed to a cryogenic condenser to condense remaining tobacco-derived compounds as frost. The tobacco-derived

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compound-containing frost may then be recovered. Of course, cryogenic condensation may be employed without prior higher temperature condensation.

Condensation may be carried out using conventional techniques. For example, the gas stream may be led to a condenser system. The condenser system can be operated at a temperature sufficiently low to condense most of the tobacco compounds from the gas stream. A temperature of below about 50°C may be suitable although cooling to below 30°C is preferred. Preferably more than one condenser is used; each succeeding condenser being operated at a lower temperature than the previous condenser. Preferably the downstream-most condenser is operated at a temperature of about 0°C to about 10°C.

If it is desired to concentrate the tobacco-derived compounds using partial condensation, the gas stream may be subjected to a first condensation step at a high temperature; for example at about 80°C to about 95°C. This will result in the condensation of primarily water. The non-condensing and concentrated tobacco-derived compounds may then be subjected to a second condensation step at a lower temperature; for example at about 0°C to about 50°C to provide a composition comprising the tobacco-derived compounds.

The composition comprising the tobacco-derived compounds removed from the condenser system contains tobacco-derived compounds which may be used to provide flavor, aroma, or other sensory attributes to other compositions, such as aerosol-generating compositions for use in heated aerosol-generating smoking devices.

Tobacco-derived compounds that do not condense in the condenser system may be directed to a cryogenic condenser for collection. Many suitable cryogenic condensers are known and have been reported in the literature. Examples include the cryogenic condensers described in U.S. Pat. Nos. 5,182,926 and 5,323,623; the disclosures of which are hereby incorporated herein by reference in their respective entireties to the extent that they do not conflict with the disclosure presented herein. Further details of the operation of such cryogenic condensers may be obtained from the disclosures in the patents. Of course other cryogenic aroma condensers may be used; for example those disclosed in U.S. Pat. No. 5,030,473. The tobacco-derived compounds collected in the cryogenic condenser is in the form of a frost. The frost may be used to flavor or to provide aroma or other attributes to compositions such as

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aerosol-generating compositions for use in heated aerosol-generating smoking devices. Alternatively, the frost may be combined with a suitable carrier substrate such as an oil or an oil-containing emulsion. This tobacco-derived compound-containing carrier can be conveniently added to compositions to provide flavor or the like.

5 If desired, the tobacco-derived compounds may be concentrated prior to being added to a composition to provide flavor, aroma or the like. Concentration may be carried out using conventional procedures such as partial condensation, rectification, membrane concentration and freeze concentration.

10 In embodiments, tobacco-derived compounds recovered from a gas stream may be passed through oil which can extract or absorb one or more of the tobacco-derived compounds. The tobacco-derived compound enhanced oil can be included in aerosol-generating compositions for use in heated aerosol-generating devices.

 Compositions containing tobacco-derived compounds can be fractionated to form compositions having different constitution of tobacco-derived compounds. In some
15 embodiments, fractionation can be accomplished by carrying out condensation of the gas stream composition at different temperatures to collect different fractions at different temperatures. It will be understood that a compound's vapor pressure or boiling point, or concentration, may affect the concentration of the compound in various fractions obtained via condensation at different temperatures. Compounds with similar vapor
20 pressures or boiling points will tend to be present in the same fractions. Fractions may be subjected to testing for the presence of certain compounds that can serve as markers for other compounds that may be present in the fraction, regardless of the fractionation process employed. Boiling points of exemplary tobacco-derived compounds are provided in Table 1 and can be used to devise condensation or
25 fractionation protocols by one of skill in the art.

 Other fractionation processes that may be used include distillation, extraction, and the like. Preferably, fractionation is performed to obtain compositions having higher ratios of tobacco flavorants to non-flavorant tobacco-derived compounds.

30 The concentration of one or more tobacco-derived compound in a fraction or a composition can be enhanced through any suitable method, if desired.

 One or more recovered tobacco-derived compounds or compositions, such as fractions, containing recovered tobacco-derived compounds may be included in an

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aerosol-generating composition for use in heated aerosol-generating device. Heated aerosol-generating devices include electronic cigarettes or electronic pipes that simulate one or more aspects of the act of tobacco smoking by producing an inhaled aerosol having the one or more of the appearance, the physical sensation, the flavor and the nicotine content of inhaled tobacco smoke.

Any suitable electronic smoking device may be employed. Typically electronic smoking devices include an atomizing element, for example, a nebulizer or atomizer, which uses heat to vaporize contents of a cartridge containing an aerosol-generating composition which is inhaled by a user. The cartridge containing the aerosol-generating composition or e-liquid typically contains a propylene glycol- or glycerin-based aqueous solution. The heating element can be controlled by a computer chip that is activated by the inhalation or "draw" of the user on the end of electronic smoking devices. The heating element and the computer chip can be operably coupled to a battery or other suitable power source. In many embodiments, the opposite end of electronic smoking devices will include a light that glows when the device is being "smoked" or drawn upon by the user to simulate the appearance of smoking.

Aerosol-generating devices may be of a single-use or disposable type, or may be refillable with liquid compositions or cartridges containing aerosol-generating compositions for use in heated aerosol-generating devices.

Embodiments of the present invention are directed to compositions for use in aerosol-generating devices that contain recovered tobacco-derived compounds, and cartridges for electronic smoking devices that contain compositions comprising recovered tobacco-derived compounds. In one aspect, a cartridge for an aerosol-generating device contains a liquid composition comprising a solvent or carrier and one or more recovered tobacco-derived compounds obtained as described above.

Aerosol-generating compositions for use in heated aerosol-generating devices may include any suitable amount of recovered tobacco-derived compounds. In embodiments, the composition comprises between about 0.5% to about 15%, often from about 1% to about 10%. Unless otherwise clear from context, all percentages referred to herein are expressed as percent by weight based on the total weight of the composition. In some embodiments, the concentration of tobacco-derived compounds can be higher to allow for mixing of condensates, fractions, extracts or other such

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compositions containing recovered tobacco-derived products with other compositions, such as flavor compositions, nicotine compositions, or the like by a consumer or a formulary.

Aerosol-generating compositions of the present invention may contain other
5 components, such as one or more of water, organic solvents, sweetening agents, flavoring agents, and the like. Examples of solvents that are commonly used in such aerosol-generating compositions include polyhydric alcohols such as 1,2-propylene glycol (PG or MPG); monohydric alcohols such as ethanol; ethyl acetate; glycerol and the like. The amount of water present typically ranges from about 0.1% to about 10%,
10 usually from about 0.5% to about 5%. The cumulative total of one or more organic solvent present typically ranges from about 50% to about 99%, often from about 75% to about 95%. In a preferred embodiment, an aerosol-generating composition comprises polyethylene glycol in a range from about 25% to about 90% and comprises propylene glycol in a range from about 9% to about 50%. In some preferred embodiment, an
15 aerosol-generating composition comprises polyethylene glycol and glycerol.

In some preferred embodiments, an aerosol-generating composition is formulated with one or more aqueous composition comprising nicotine, propylene glycol, glycerol or a combination of at least two or more of nicotine, propylene glycol and glycerol.

20 In some preferred embodiments, one or more tobacco-derived compounds are added to a base composition to form an aerosol-generating composition. Preferably, the base composition comprises propylene glycol, glycerol and water. For example, the base composition may comprise about 48% to about 68%, preferably about 58%, propylene glycol, about 25% to about 45%, preferably about 35%, glycerol, and about
25 2% to about 12%, preferably about 7%, water.

If desired, compositions of the present invention may include one or more flavorants in addition to recovered tobacco-derived compounds that may be flavorants. Non-limiting examples of such additional flavorants include peppermint, menthol, wintergreen, spearmint, propolis, eucalyptus, cinnamon, or the like. The total amount of
30 optional flavorants typically ranges from about 0.5% to about 15%, often from about 1% to about 10%.

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Aerosol-generating compositions of the present invention may contain any suitable amount of nicotine. For example, the compositions may contain 0% to about 30% nicotine. Preferably, the compositions of the present invention comprise about 0.5% to about 18% nicotine.

5 All scientific and technical terms used herein have meanings commonly used in the art unless otherwise specified. The definitions provided herein are to facilitate understanding of certain terms used frequently herein.

As used herein, the singular forms "a", "an", and "the" encompass embodiments having plural referents, unless the content clearly dictates otherwise.

10 As used herein, "or" is generally employed in its sense including "and/or" unless the content clearly dictates otherwise. The term "and/or" means one or all of the listed elements or a combination of any two or more of the listed elements.

As used herein, "have", "having", "include", "including", "comprise", "comprising" or the like are used in their open ended sense, and generally mean "including, but not
15 limited to". It will be understood that "consisting essentially of", "consisting of", and the like are subsumed in "comprising," and the like.

The words "preferred" and "preferably" refer to embodiments of the invention that may afford certain benefits, under certain circumstances. However, other embodiments may also be preferred, under the same or other circumstances. Furthermore, the
20 recitation of one or more preferred embodiments does not imply that other embodiments are not useful, and is not intended to exclude other embodiments from the scope of the disclosure, including the claims.

Reference to a particular compound herein includes salts, polymorphs, isomers, and hydrates of the compound unless the content clearly dictates otherwise.

25 Referring now to **FIG. 1**, schematic drawings are depicted that illustrate various aspects of a process for recovering volatile tobacco compounds from a DIET process and a smoking device that may include an e-liquid composition comprising such recovered tobacco compounds. The drawings are not necessarily to scale and are presented for purposes of illustration and not limitation. The drawings depict various
30 aspects described in this disclosure. However, it will be understood that other aspects not depicted in the drawings fall within the scope and spirit of this disclosure.

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FIG. 1 is a schematic flow diagram illustrating a process for recovering volatile compounds from a DIET process.

Referring now specifically to **FIG. 1**, a simplified overview of a DIET process in which volatile tobacco compounds are recovered is shown. The process includes contacting tobacco **100** with liquid carbon dioxide **110** to form liquid carbon dioxide impregnated tobacco **120** under pressure sufficient to maintain the carbon dioxide in liquid form. The pressure is then decreased, such as to atmospheric pressure, which results in freezing of the liquid carbon dioxide to form dry ice-impregnated tobacco **130**. The dry ice-impregnated tobacco **130** is contacted with hot gas **140** to result in expanded tobacco **150**. The resulting gas may be separated into tobacco dust **155**, process gas **145**, and tail gas **142** that contains volatile tobacco compounds. The process gas **145** may be heated and used as, at least a portion of, hot gas **140** in continued operation. The tail gas **142** is directed to recovery apparatus **200**, such as condensers or the like, where the volatile tobacco compounds are recovered. Water may be added to the expanded tobacco **150** to produce reordered tobacco **170** having a moisture content similar to the starting tobacco material **100**.

Thus, methods, systems, devices, compounds and compositions for RECOVERY OF TOBACCO CONSTITUENTS FROM PROCESSING are described. Various modifications and variations of the invention will be apparent to those skilled in the art without departing from the scope and spirit of the invention. Although the invention has been described in connection with specific preferred embodiments, it should be understood that the invention as claimed should not be unduly limited to such specific embodiments. Indeed, various modifications of the described modes for carrying out the invention which are apparent to those skilled in chemistry and chemical engineering or related fields are intended to be within the scope of the following claims.

CLAIMS:

1. A composition comprising nicotine and one or more tobacco-derived compounds,
5 wherein the one or more tobacco-derived compounds are obtained by a process comprising condensing a gas stream employed in a tobacco expansion process comprising the tobacco-derived compounds to form a condensate, and fractionating the condensate to selectively recover or enrich the one or more tobacco-derived compounds.
10
2. A composition according to claim 1, wherein the one or more tobacco-derived compounds are obtained by condensing a gas stream that is employed in a dry ice tobacco expansion process.
- 15 3. A composition according to any one of claims 1-2, wherein the one or more tobacco-derived compounds in the gas stream are generated from tobacco by volatilization at a temperature at between about 150°C and about 400°C.
4. A composition according to any one of claims 1-3, wherein the one or more
20 tobacco-derived compounds in the gas stream are obtained by treating tobacco that is impregnated with non-gaseous carbon dioxide with a gas stream comprising steam, at a temperature at between about 150°C and about 400°C, thereby volatilizing the one or more tobacco-derived compounds.
- 25 5. A composition according to any one of claims 1-4, wherein the one or more tobacco-derived compounds are obtained by condensing the gas stream in more than one stage at different temperature ranges and forming more than one condensate.
- 30 6. A composition according to any one of claims 1-5 wherein one or more of the tobacco-derived compounds is a terpene, a tobacco alkaloid, or an alkylpyrazine.

7. A composition according to any one of claims 1-6 wherein one or more of the tobacco-derived compounds that is obtained in one or more condensates by the process is selected from the group consisting of α -pinene, β -pinene, α -terpinene, limonene, eucalyptol, linalool, camphor, borneol, citronellol, β -caryophyllene, l-nicotine, l-myosmine, nicotyrine, cotinine, 3-cyanopyridine, 2-methyl-pyrazine, 2-ethyl-pyrazine, 2,3-dimethyl-pyrazine, 6-ethyl-2-methyl-pyrazine, trimethyl-pyrazine, 2-ethyl-5-methyl-pyrazine, and dimethylethyl-pyrazine.
8. An aerosol-generating composition for use in a heated aerosol-generating smoking device, comprising a composition according to any one of claims 1-7.
9. The aerosol-generating composition according to claim 7 or claim 8, wherein the composition further comprises propylene glycol and glycerol.
10. A method comprising:
Volatilizing, via a tobacco expansion process, one or more tobacco-derived compounds into a gas stream;
recovering a composition comprising at least one of the one or more volatilized constituents or reaction products from the gas stream; and
fractionating the composition to selectively recover or enrich at least one of the one or more volatilized constituents or reaction products.
11. A method according to claim 10, wherein volatilizing the one or more tobacco-derived compounds into the gas stream comprises heating tobacco impregnated with non-gaseous carbon dioxide by a gas stream comprising steam in the tobacco expansion process.
12. A method according to any of claims 10-11, wherein recovering the at least one of the one or more volatilized compounds comprises condensing the gas stream at one or more temperature ranges.

13. A method according to any claims 10-12, further comprising introducing one or more of the recovered tobacco-derived compounds to an aerosol-generating composition for use in a heated aerosol-generating smoking device.

5 14. A method for preparing an aerosol-generating composition for use in a heated aerosol-generating smoking article, comprising:
formulating the composition according to any one of claims 1-7 with one or more aqueous composition comprising nicotine, propylene glycol, glycerol or a combination of at least two of the foregoing substance.

10 15. A method according to claim 10, wherein volatilizing the one or more tobacco-derived compounds comprises dry ice tobacco expansion, the method further comprising:
selectively recovering or enriching a fraction comprising tobacco-derived
15 compounds; and
formulating an aerosol-generating composition with the fraction and an aqueous composition comprising nicotine and propylene glycol, glycerol, or a combination thereof.