

**ATMOSPHERIC PRESSURE ION SOURCE  
MOVING TRANSPORT INTERFACE FOR A  
MASS SPECTROMETER**

PATENTS CITED DIRECTLY RELATING TO  
THIS INVENTION

**[0001]** U.S. Pat. No. 4,055,987, William H. McFadden, Finnigan Corp., "Liquid Chromatograph/Mass Spectrometry Interface".

**[0002]** U.S. Pat. No. 4,867,947A, Brian D. Andresen and Eric R. Fought, Sepragen Corp., "Interface for Liquid Chromatograph-Mass Spectrometer".

NON-PATENT CITATIONS DIRECTLY  
RELATING TO THIS INVENTION

**[0003]** Smith, R. D. et al., *Deposition Method for Moving Ribbon Liquid Chromatograph-Mass Spectrometer Interfaces*, Anal. Chem., 1981, 53, 739-740.

**[0004]** Smith, R. D. et al., *Liquid Chromatography-Mass Spectrometry with Electron Impact and Fast Atom Bombardment with a Ribbon Storage Device*, Anal. Chem., 1981, 53, 1603-1611.

**[0005]** Hayes, M. J. et al., *Moving Belt Interface with Spray Deposition for Liquid Chromatography/Mass Spectrometry*, Anal. Chem., 1983, 55, 1745-1752.

**[0006]** Games, D. C. et al., *A Comparison of Moving Belt Interfaces for Liquid Chromatography-Mass Spectrometry*, Biomed. Mass Spectrom., 1984, 11, 87-95.

**[0007]** Stout, S. D. et al., *Simplified Moving Belt Interface for Liquid chromatography/Mass Spectrometry*, Anal. Chem., 1985, 57, 1783-1786.

**[0008]** Mizuno, T. et al., Development of double Belt Type LC/MS Interface without Memory Effect, Anal. Sci., 1988, 4, 241-246.

**[0009]** Barefoot, A. C. et al., *Packed Capillary Liquid Chromatography/Mass Spectrometry Using a Moving Belt Interface*, Biomed. Environ. Mass Spectrom., 1989, 18, 77-82.

**[0010]** Horning, E. C., et al., *New Picogram Detection System Based on a Mass Spectrometer with an External Ionization Source at Atmospheric Pressure*, Anal. Chem., 1973, 45, 936-943.

**[0011]** Dzidic, et al., *Comparison of Positive Ions Formed in Nickel-63 and Corona Discharge Ion Sources using Nitrogen, Argon, Isobutene, Ammonia, and Nitric Oxide as Reagents in Atmospheric Pressure Ionization Mass Spectrometry*, Anal. Chem., 1976, 48, 1762-1768.

**[0012]** McEwen, C. N., et al., Analysis of Solids, Liquids and Biological Tissue Using Solids Probe Introduction at Atmospheric Pressure on Commercial LC/MS Instruments, Anal. Chem., 2005, 77, 7826-7831

FIELD OF INVENTION

**[0013]** This invention relates to an atmospheric pressure ionization (API) source comprising ionization of liquid effluents either by electrospray (ESI) or atmospheric pressure chemical ionization (APCI) and also facilitates rapid analysis of solid or liquid samples by direct introduction into the API source on a moving ribbon, wire, or belt of an analyte transport device (ATD) to permit ionization and subsequent mass separation of the ions by a mass spectrometer. This invention also relates to a method, using the ionization source, of introducing the analyte on the surface of a heat tolerant material

into a heated nitrogen stream which may emanate from either a commercial ESI or APCI probe so that the analyte is vaporized with subsequent ionization using either a discharge or photoionization. This invention also relates to a method, using the ionization source, of increasing the compounds that can be ionized in an API source by eliminating solvent that hinders or prevents ionization of nonpolar analytes. This invention also relates to use of automation such as robotics or liquid or gas chromatographic auto-samplers to place or inject samples, usually in solution, onto the moving ribbon, wire, or belt of the ATD for subsequent vaporization and ionization in an API source. This invention also relates to depositing the eluent from a liquid chromatograph onto the moving ribbon, wire, or belt of the ATD for subsequent vaporization of the chromatographically separated components of a mixture and ionization at atmospheric pressure with analysis using a mass spectrometer or ion mobility spectrometer. This invention also relates to removing the solvent from samples placed on the moving ribbon, wire, or belt of the ATD before the sample enters the housing that encloses the atmospheric pressure ion source.

**[0014]** As used in this invention a moving ribbon, wire, or belt, hereafter called a moving transport device (ATD) are a means of introducing sample into the ionization region of a mass spectrometer. Sample can be placed on the ATD using robotics that are commonly used in mass spectrometry or auto-samplers commonly used with separation devices such as liquid chromatographs, or by hand with, for example, a pipette. The ESI and APCI probe assemblies are commercially available and present on most API sources. The ATD assembly used to introduce samples into the API source is similar in many respects to so called moving belt interface devices used to introduce samples into electron or chemical ionization sources that operate under vacuum conditions, except that vacuum locks are not required for the ATD which greatly simplifies the device. Additionally, ionization is at atmospheric pressure which makes the method useful for modern mass spectrometers used in combination with liquid chromatography. The ATD also preferably uses the heated gas stream, usually nitrogen, from the commercially available ESI or APCI probes for sample vaporization rather than resistive heating of the surface containing the sample.

**[0015]** Employing the ionization source of the present invention, a single atmospheric pressure ionization mass spectrometer of any type is made capable of ionizing with high sensitivity low-polarity compounds that are difficult to ionize using the commonly available ionization methods of ESI or APCI. In combination with robotics or auto-samplers, the method allows rapid automatic introduction of samples without solvent into the atmospheric pressure ionization region for analysis by mass spectrometry. The method can also be used in combination with liquid separation techniques to facilitate ionization of low polarity compounds with high sensitivity.

BACKGROUND

**[0016]** As used herein, the term moving transport device (ATD) refers to a device incorporating a heat resistant ribbon, wire or belt that moves analyte from the exterior of the atmospheric pressure ion (API) source of a mass spectrometer through the ion source housing to the interior of the source and a flange assembly that holds the ATD to the ion source housing. The term ESI probe refers to a commercially available device for ionization of analyte in a liquid stream using