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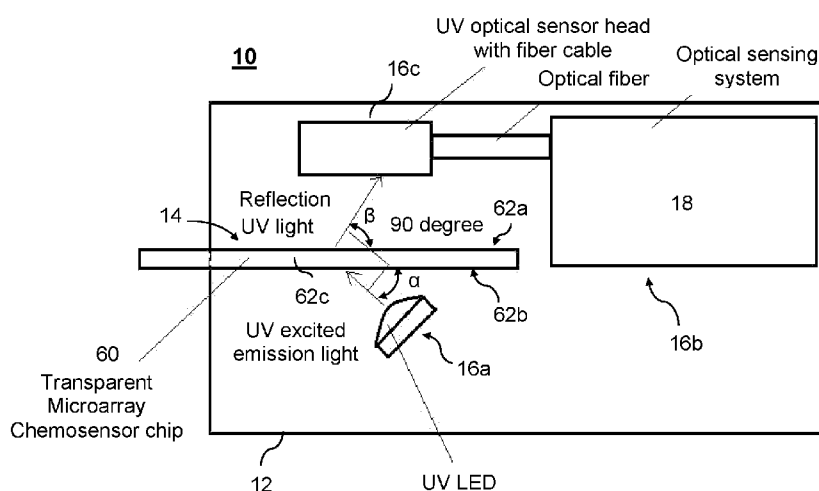


Fig. 2

(57) Abstract: A detection apparatus for detection of an organic compound, wherein the apparatus comprises a sample receptacle for receiving a sample, an optical arrangement for emitting a source optical signal towards the sample and for detecting a responsive optical signal from the sample, and a processor to determine qualitative and/or quantitative information of the organic compound in the sample according to solvatochromic properties of the sample.

DETECTION OF ORGANIC COMPOUNDS

Field

[0001] The present disclosure relates to detection of organic compounds, and more particularly, the detection of phthalates and phthalate-based organic compounds.

5 Background

[0002] Organic compounds are widely present in the environment. Rubber, plastics, fuel, pharmaceutical, cosmetics, detergent, coatings, dyestuff, volatile organic compounds, and agrichemical substances, to name a few, are example organic compounds which are present in the environment and which people come in contact almost on a daily basis. Some organic compounds are harmful, non-friendly, or noteworthy.

[0003] Plasticizers or dispersants are organic compound additives that enhance the plasticity or fluidity of a material. While plasticizers are primarily used in plastics, especially polyvinyl chloride (PVC), plasticizers are also blended in other materials including concrete, clays, and related products to improve or modify their properties.

[0004] While plasticizers are useful, prolonged exposure to some plasticizers has been known to pose health risks. For example, long-term exposure to DEHP is found to affect the liver and kidney as well as the reproduction and development of experimental animals. DEHP is classified as possibly carcinogenic to humans. Compared with DEHP, DINP has lower toxicity. Chronic large-dose exposure to DBP was found to affect the reproduction and development and cause birth defect in experimental animals.

[0005] Currently, plasticizers and other organic compounds are typically detected using gas chromatography mass spectrometers (GC-MS) which are bulky, expensive and requires tedious operation procedures.

[0006] Simple and expedient detection schemes and detection apparatus of reasonable accuracy for detection of plasticizers and other organic compounds are therefore desirable.

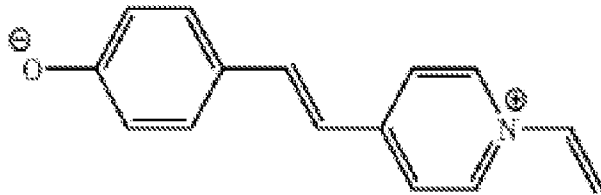
Disclosure

[0007] An organic compound detector is disclosed. The detector comprises a solvatochromic molecularly imprinted polymer ("SMIP") which is affinitive or complementary to a target organic compound, and the molecular imprinted polymer (or more specifically, its solvatochromic functional group such as its solvatochromic functional monomer) is to change colour when the target organic compound is captured by or coupled with the SMIP.

[0008] In some embodiment, the molecularly imprinted polymer is for capturing an organic compound comprising one or more than one functional group as shown in Tables 1A-1H.

[0009] In some embodiment, the detector is having receptor site that is affinitive or complementary to a target phthalate or a phthalate-based plasticizer. The target phthalate or the phthalate-based plasticizer is any one of the phthalate shown in Table 3.

[0010] In some embodiment, the molecular imprinted polymer comprises a solvatochromic functional monomer having the structure:



[0011] Since a molecularly imprinted polymer can be tailor-made for or to bind with a specific organic compound, and more particular to bind with a specific or characteristic functional group of the specific organic compound, the detector is specific for the specific organic compound, in particular organic compound having a particular functional group. Qualitative analysis and quantitative analysis can be achieved without (or with less) interference and unstable test result due to a mix of different organic compounds in a sample can be mitigated. It is a unique solvatochromic property of a solvatochromic MIP that the wavelength distribution and/or intensity of a characteristic wavelength of a composite analyte formed by capturing of a target organic compound by a solvatochromic MIP changes with changing concentration of the composite analyte, and this unique solvatochromic property is utilized herein to facilitate rapid and efficient solvatochromic detection of organic compounds.

[0012] A method of detecting presence and/or determining concentration of a target organic compound in a sample is disclosed. The method comprising dissolving a target sample in an organic solvent to obtain a sample solution; applying a probing device to the sample solution to form a target analyte, the probing device comprising a solvatochromic molecularly imprinted polymer or SMIP, and the SMIP comprising a solvatochromic functional group or a solvatochromic functional monomer the colour and/or fluorescence properties of which will change upon coupling or encountering the target organic compound or when the target organic compound is captured by the SMIP; and detecting or determining presence and/or concentration of the target organic compound with reference to colorimetric, luminescent and/or fluorescent response of the target analyte.

[0013] A detection apparatus for detection of organic compound is disclosed. The apparatus comprises a sample receptacle for receiving a sample, an optical arrangement for emitting a

source optical signal towards the sample and for detecting a responsive optical signal from the sample, and a processor to determine qualitative and/or quantitative information of the organic compound in the sample according to solvatochromic properties of the sample, for example, according to solvatochromic properties and/or with reference to colorimetric, luminescent and/or fluorescent response of the target analyte. The target analyte comprises analyte composites and each analyte composite comprises a probing device and a target organic compound or at least a characteristic functional group thereof. The probing device comprises a solvatochromic molecularly imprinted polymer or SMIP, and the SMIP comprises a solvatochromic functional group or a solvatochromic functional monomer. The colour and/or fluorescence properties of the solvatochromic functional group or the solvatochromic functional monomer is to change upon encountering or coupling with the target organic compound.

[0014] The detector is light weight, portable and low-cost while providing rapid, reasonably accurate and cost-effective test results. The detector is particularly useful for a small buying office, retailer and manufacturing factory to help determine whether materials of a finished product do comply with concentration limits or allowance of specific types of organic compounds, for example, limit of phthalate or plasticizers in accordance with the requirements of part three of ASTM F963 of CPSC and part three of EN71 of 2009/48/EC.

[0015] A sample extraction apparatus for rapid extraction of samples to facilitate detection of an organic compound or organic compounds is also disclosed. The apparatus comprises a heating chamber and an enclosed sample container. The enclosed sample container has a bottom portion and an enclosed upper portion. The heating chamber is for heating sample on the bottom portion for sample collection at the enclosed upper portion.

[0016] A method of organic compound sample extraction for quantitative or concentration determination is disclosed. The method comprising placing a first predetermined weight of an organic compound containing sample inside a sample container and closing the sample container to form an enclosed sample container, the enclosed sample container comprising a bottom portion, a top portion and an upper portion comprising an intermediate wall dependent from the top portion; heating the bottom portion of the sample container to vaporize the organic compound to deposit on the top and/or upper portions of the enclosed sample container when the sample is on the bottom portion of the enclosed sample container; and dissolving the organic compound from the sample container in a second predetermined amount of a polar organic solvent.

[0017] In some embodiments, the method of organic compound sample extraction is performed with ethanol as the solvent. In some embodiments, the heating is performed at high temperature under sealed conditions.

[0018] The method of sample extraction facilitates operation by personnel with limited or no chemical background since a non-toxic solvent, such as ethanol, may be used.

[0019] Therefore, there is provided, in combination, a sample extraction apparatus, a organic compound detection and/or a detection apparatus for detection of a target organic compound in a sample, as disclosed herein.

[0020] The use in combination of a novel extraction device, a detection apparatus, and solvatochromic MIP capture reagents disclosed herein facilitates solvatochromic MIP capture reagents disclosed herein facilitates rapid screening tests while achieving a reasonably high sensitivity and accuracy, for example, 40-100 ppm with solid or liquid material samples. As an example, sample extraction can be done 4-6 times faster than sample extraction using conventional pre-chemical (extraction) processes, the MIP reagent test can take less than one minute to perform qualitative analysis and less than 3 minutes to perform quantitative analysis under UV optical sensing. Furthermore, as different MIP capture reagents function or operate independently to capture different target organic analytes, interference and instability such as those which would occur in FTIR is mitigated and barriers in the application of anti-body for alcohol, milk or liquid samples can be mitigated.

[0021] As solvatochromic MIP capture reagents are low-cost chemosensing agents which are stable and therefore more suitable for long term storage, for example due to its inert polyacrylate material, and which can achieve a higher detection sensitivity, using solvatochromic MIP capture reagents to detect quantitatively and/or quantitatively organic compounds such as phthalates and plasticizers provides a useful alternative to rapid material testing.

Figures

[0022] The disclosure will be described by way of example with reference to the accompanying Figures, in which:

Figure 1 is a schematic diagram depicting an example detection arrangement with a sample carrier in operational position,

Figure 2 is a schematic diagram depicting an example detection apparatus,

Figure 3 is a schematic diagram of an example card-shaped detector,

Figure 4A-4J are curves showing example solvatochromic light emission properties of analytes having different target analyte concentrations,

Figures 5A and 5B show graphs of relative light emission intensity and phthalate concentration of several captured phthalate analytes in ethanol,

- 5 Figure 6A is a graph showing correlation between emission light intensity and concentration of SMIP-DnOP composite analytes,

Figure 6B is an example calibration curve of a detection apparatus,

Figure 7 is a schematic diagram depicting an example detector,

- Figure 8 is a schematic diagram of an example optical arrangement to cooperate with the
10 detector of Figure 7 to perform solvatochromic optical measurements,

Figure 9 is a schematic diagram of a detection apparatus to cooperate with the detector of Figure 7 and optical arrangement of Figure 8,

Figure 10 is a schematic diagram depicting an example detector,

- Figure 11 is a schematic diagram of an example optical arrangement to cooperate with the
15 detector of Figure 10 to perform solvatochromic optical measurements,

Figure 12 is a schematic diagram of a detection apparatus to cooperate with the detector of Figure 10 and optical arrangement of Figure 11,

Figure 13 is a schematic diagram of an example detector and an example optical arrangement to cooperate with the detector of Figure 10 to perform solvatochromic optical measurements,

- 20 Figure 14 is a schematic diagram of a detection apparatus to cooperate with the detector of Figure 13,

Figure 15 is a schematic diagram of a sample collection apparatus,

Figure 15a is a schematic diagram depicting example operation of a sample collection apparatus,

- 25 Figure 16a is a schematic diagram showing part of a sample extraction container, and

Figure 16b is a schematic diagram showing a sample extraction container.

Description

- [0023] An example detection arrangement 10 comprises an optical compartment 12, a sample receptacle defining a sample compartment 14, an optical arrangement 16 and evaluation
30 circuitry 18, as depicted in Figure 1. The optical arrangement comprises an optical source 16a and an optical receiver 16b which is connected to a optical sensing head 16c, as depicted in

Figure 2. The optical source 16a is arranged to transmit an optical source signal towards a sample or a plurality of samples carried on a sample carrier and received inside the sample compartment 14 during sample examination operations and the optical receiver 16b is arranged to receive and detect an optical response signal or optical response signals coming from the sample in response to the optical source signal impinging on the sample. To facilitate detection of optical response signals, the optical receiver includes an optical sensor head 16c and signal processing circuitry, for example, a microprocessor based signal processing circuitry, for processing output of the optical sensor head 16c. The signal processing circuitry may include an output for outputting processed signals and data storage devices for storing recorded output spectrum and analyses data.

[0024] The sample compartment 14 is arranged to receive and hold a sample carrier, for example, in a closely fitted manner, during sample examination operations. A sample carrier fixture may be formed inside the sample compartment to releasably hold the sample carrier at a predetermined examination position inside the sample compartment. The sample carrier defines a sample receptacle and is arranged so that when a sample carrier is being held at the predetermined detection position during sample examination operations, the optical source signal emitted from the optical source 16a will impinge on the sample or samples carried on the sample carrier and the optical response signal will be forwarded to the optical sensor 16c in response to the optical source signal encountering the sample or samples carried on the sample carrier. The optical sensor 16c will generate an output signal when the optical response signal reaches the optical sensor 16c during sample examination operations, and the signal processing circuitry of the optical receiver 16b will then generate processed output to the evaluation circuitry in response to the detection of the optical response signal for further processing and/or evaluation by the evaluation circuitry.

[0025] The evaluation circuitry may comprise a processor and peripheral circuits. The processor may comprise a microprocessor or a microcontroller and the peripheral circuits may comprise signal processing circuits, decision circuits, input/output circuits and data storage devices such as volatile and non-volatile memories for storing instructions and data. During sample analysing operations, the processor of the evaluation circuitry is to evaluate qualitative and/or quantitative characteristics optical properties of the received optical response signal to determine and output qualitative and/or quantitative characteristics of the sample analyte or sample analytes carried on the sample carrier by execution of stored instructions and with reference to stored data and/or decision criteria.

[0026] The sample carrier is to be removed from the sample receptacle after sample examination has been performed so that another sample carrier can be received for another

sample examination operation to take place. The sample fixture may include a releasable latch for releasably holding the sample carrier in the predetermined examination position.

[0027] An example detection apparatus 100 comprises a main housing 40 and the detection arrangement 10 which is mounted inside the main housing 40, as depicted in Figure 1. The main housing 40 is adapted for portable applications and is shaped and dimensioned for portability and hand-carried mobility. The detection apparatus 100 may be powered by a battery power source inside the main housing or may obtain operational power from an external source, for example, a DC power supply or through a USB connector.

[0028] The optical arrangement 16 and the evaluation circuitry 18 are mounted on a main printed circuit board 42 and the main printed circuit board 42 is in turn mounted and enclosed inside the main housing 40. The example optical source comprises an LED which is mounted on an upper surface of the main printed circuit board ("PCB") and has its light emitting surface facing upwards. The optical sensor includes an optical sensor head and an optical sensor module which supports the optical sensor. Output of the optical sensor module is connected to a microcontroller, for example, the microprocessor inside the optical receiver. The optical compartment and the sample receptacle are both inside the main housing and are defined between the optical source and the optical sensor. The peripheral circuits include a data output port which is mounted on the main printed circuit board. The main housing includes an aperture at its rear end so that an external data connector can be connected to the microcontroller for data delivery. In example embodiments, the peripheral circuits may include wireless data transmission arrangements such as a WiFi device so that measurement data can be transmitted to external devices such as computers, routers or smart-phones installed with appropriate application software.

[0029] In example embodiments, solvatochromic MIP capture reagents for capturing a target organic compound or a plurality of target organic compounds are distributed on a sample carrier, for example, in a matrix form. In example applications, the sample carrier is a sensor chip in the form of a transparent sample-carrying card 60 having a first major side 62a, a second major side 62b and a peripheral side 62c interconnecting the first and the second major sides. The sample-carrying card 60 comprises a card-shaped substrate which may be made of transparent hard plastics. As depicted in Figure 3, a plurality of sample sites is deposited on the first major side 62a or the second major side 62b and each sample site carries a solvatochromic MIP capture reagent. The solvatochromic MIP capture agents may be all of different types and may have duplications to provide testing redundancy and each sample site appears as a sample dot on the sample carrier, as depicted in Figure 3. In some embodiments, the sensor chip may be for detection of a specific type of organic compound and the sample site or sample sites may be deposited with a single type of solvatochromic

MIP capture agents. In some embodiments, the sample sites may carry other types of chemosensors without loss of generality.

[0030] So that the card-shaped sample carrier can be held firmly in an analyte examination position for proper sample examination, the sample receptacle may comprise a sample card holding fixture. The sample card holding fixture may include a mounting fixture which is mounted on the main printed circuit board and arranged to firmly hold the sample-carrying card at an examination position when the sample carrier is inserted into the main housing through the sample carrier receiving slot or aperture. When the sample-carrying card is at the examination position, the source LED light will be underneath the sample-carrying card to project a source optical signal towards target locations on the sample-carrying card where samples containing captured analytes in the form of solvatochromic molecularly imprinted polymers ("*SMIP*") bound with corresponding matched target analyte as composite analytes are held.

[0031] So that the sample-carrying card can move into the examination position from outside the detection apparatus, a sample carrier receiving slot or aperture is formed on a front end of the main housing to correspond to the location of the sample receptacle to provide an entrance to the sample receptacle inside the optical compartment. The optical sensor head is above the sample receptacle for receiving optical response signal coming from the upper surface of the sample-carrying card.

[0032] When the sample-carrying card 60 is received inside the main housing 40 and held by the mounting fixture, the sample-carrying card 60 extends along a longitudinal direction X and is held intermediate the optical source 16a and the optical sensor 16c, with its upper surface facing the optical sensor 16c and its lower surface facing the optical source 16a. The optical source 16a is arranged to emit an optical source signal towards the lower major side of the sample-carrying card 60 and at a first angle α to the longitudinal direction. The optical response signal is to emerge from the upper major side of the sample-carrying card and the optical sensor 16c is arranged for collecting a response optical signal which is to travel from the target location at a second angle β to the longitudinal direction. In the example arrangement of Figure 2, the response optical signal travels at right angle to direction of the optical source signal. The sample-carrying card having a substrate is made of a transparent or translucent plastic material so that the optical source signal after impinging on the underside of the sample-carrying card at the first angle α will emerge at the top side of the sample carrier card at the second angle β and towards the optical sensor.

[0033] In some embodiments, the sample carrier is a test tube or other transparent container and the sample receptacle will be correspondingly shaped and adapted for its reception so that due examination can be performed.

[0034] In example embodiments, the optical source 16a is arranged to emit an optical excitation signal of a first frequency towards samples carried on a sample carrier and the optical receiver 16b is arranged to detect a target optical response signal that is characteristic of the target analyte when subject to excitation illumination by the target optical excitation signal.

[0035] Solvatochromism and molecular imprinting technique are utilized in combination to facilitate qualitative and/or quantitative detection of organic compounds herein. Organic compounds having the example functional groups listed in Tables 1A-1H are suitable for solvatochromic capturing by corresponding SMIPs. While the example functional groups are those of phthalates or phthalate-based plasticizers, the detection methods, techniques and appliances herein are applicable to organic compounds having other functional groups without loss of generality. A molecularly imprinted polymer ("MIP") having a receptor site that is suitable for capturing a target organic compounds and a solvatochromic functional group that changes colour and/or fluorescence properties upon capture of the target organic compounds is devised as a "*solvatochromic MIP probe*" or "SMIP probe" in short.

[0036] A molecularly imprinted polymer ("MIP") is a polymer that has been processed using the molecular imprinting technique to devise a receptor site that is affinitive or complementary to the target organic compounds. Solvatochromism is the ability of a chemical substance to change color due to a change in media polarity. The design and selection of a MIP probe comprising an effective template and a solvatochromic monomer suitable for capturing a target analyte with selected or preferred solvatochromic properties has been discussed in US Patent no. US 8338, 553; the article entitled "How to find effective functional monomers for effective molecularly imprinted polymers?", *Advanced Drug Delivery Reviews* 57 (2005) 1795-1808, and "Optimization, evaluation, and characterization of molecularly imprinted polymers", *Advanced Drug Delivery Reviews* 57 (2005) 1779-1794, all of which are incorporated herein by reference.

[0037] An SMIP herein comprises a solvatochromic functional monomer which is incorporated as a reporter site within a molecularly imprinted polymer. The solvatochromic functional monomer has a characteristic media polarity and the media polarity changes when a target analyte matched with the solvatochromic functional monomer enters into the reporter site of the molecularly imprinted polymer. As a solvatochromic functional monomer is highly sensitive to the change of the media polarity of receptor micro-environment, the displacing of

solvent molecules originally occupying the receptor site by an analyte having a matched solvatochromic functional monomer on entering into the reporter site will bring about a significant change in color and/or luminescent properties of the solvatochromic functional monomer, and the changes can be detected by naked eyes or by spectrum measurement. As
5 intermolecular interaction between a target analytes and the functional monomer is not required in forming a solvatochromic composite, analytes lacking the ability of intermolecular interaction can be detected by SMIP chemosensing approach.

[0038] By devising a molecularly imprinted polymer having a solvatochromic receptor site which incorporates a solvatochromic functional group that is affinitive or complementary to a
10 target organic compound, the change in colour and/or change in fluorescence properties when the target organic compound is captured, is noted and utilized to facilitate qualitative and/or quantitative determination of the presence of a target analyte comprising an organic compound.

[0039] Therefore, solvatochromic molecularly imprinted polymers ("*SMIP*") suitable for
15 capture of organic compound and having a solvatochromic functional monomer that changes colour and/or changes fluorescence properties when the target organic compound is captured are utilized as solvatochromic probes for detection of organic compounds. For example, by fabricating a molecularly imprinted polymer based solvatochromic chemosensor having one or more than one receptor site that is affinitive or complementary to the functional group listed
20 in Table 1A-1H, the solvatochromic functional monomer of the molecularly imprinted polymer based solvatochromic chemosensors will change colour and/or its fluorescence properties when an organic compound having the one or more than one functional group listed in Table 1A-1H is recognized or recognized upon capturing, qualitative and/or quantitative determination of the organic compound can be performed.

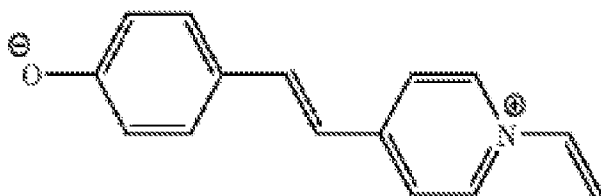
[0040] In example embodiments where a molecularly imprinted polymer is designed
25 specifically to recognize or capture a target phthalate or a target phthalate-based plasticizer and having at least one solvatochromic functional group, which changes colour and/or fluorescence properties when the target phthalate or the target phthalate-based plasticizer is captured. Such a probe is referred herein as "SMIP plasticizer probes" herein.

[0041] Specific binding constants, non-specific binding constants, and density of imprinted
30 binding sites between various example SMIPs and their corresponding target organic compounds as obtained from experimental results and Scatchard analyses are tabulated in Table 2 below:-

Phthalate	Specific binding constant / M^{-1}	Non-specific binding constant / M^{-1}	Density of imprinted binding sites / $mmol\ g^{-1}$ -MIP
DMP	1.10×10^5	2.08×10^3	0.11
DEP	1.20×10^5	2.37×10^3	0.21
DBP	1.10×10^5	5.99×10^3	0.22
DNOP	9.40×10^4	6.74×10^3	0.13
DIDP	1.20×10^5	3.24×10^3	0.21
DEHP	1.14×10^5	8.33×10^3	0.20
DNHP	9.10×10^4	0.63×10^3	0.25
DINP	1.60×10^5	0.52×10^3	0.17
BBP	1.20×10^5	5.94×10^3	0.22

Table 2

[0042] An example solvatochromic functional monomer which is suitable for forming a solvatochromic chromophore inside a receptor site for example application of plasticizer detection has the structure below:



5

[0043] In an aspect, the detection arrangement 10 is arranged to examine solvatochromic properties of sample analytes in order to determine presence of a target analyte or target analytes in a sample qualitatively and/or quantitatively.

10 [0044] In some embodiments, the processor is to determine concentration of a target analyte or target analytes in the sample according to detected solvatochromic properties exhibited by the target analytes when subject to the optical excitation signal.

15 [0045] Solvatochromic characteristics of various example composite analytes of phthalates when subject to an excitation light are depicted in Figures 4A to 4J. Each type of phthalate composite is a composite analyte comprising an example target phthalate captured by an example SMIP probe which is designated for capturing the target phthalate. In the Figures, the vertical axis or Y-axis represents output light intensity and is in intensity units, the horizontal axis or X-axis represents output light wavelengths and is in wavelength units in nm,

and the example excitation light is at 400nm. It will be apparent from Figures 4A to 4J that the intensity of the output light, and more particularly, the peak intensity of the output light, changes with changes in the concentration of the composite analytes.

[0046] Referring to Figure 4A, the example SMIP probe is devised for capturing DnOP (Di(n-octyl) phthalate, $C_8H_4[COO(CH_2)_7CH_3]_2$, molecular weight=390.56, CAS no.=117-84-0) in ethanol and the curves show intensity of emitted light of different wavelengths in nanometer (nm) at different concentrations of the composite analyte (DnOP+SMIP). It is noted that the emitted light has wavelengths of between 425nm and 745nm and of different intensities when subject to excitation by an excitation optical signal having a wavelength in the ultra-violet (UV) region, for example a wavelength of 400nm.

[0047] Referring to Figure 4A, the highest curve corresponds to light intensity characteristics of a target analyte having a target composite analyte concentration of 2,000ppm, the second highest curve corresponds to light intensity characteristics of a target analyte having a target composite analyte concentration of 1,500ppm, the third highest curve corresponds to light intensity characteristics of a target analyte having a target composite analyte concentration of 1000 ppm, the fourth highest curve corresponds to light intensity characteristics of a target analyte having a target composite analyte concentration of 700 ppm, the fifth highest curve corresponds to 500 ppm etc., and the lowest curve is at zero composite analyte concentration (0.00 ppm).

[0048] It is noted from the curves of Figure 4A that the peak light emission intensity of the example target analyte always occurs at or around 500nm and the peak intensity of the emitted light generally increases with increasing concentration (or decreases with decreasing concentration) of the target composite analyte. The peak light emission frequency and the light emission spectrum may be considered as a characteristic parameter of the solvatochromic functional monomer of the SMIP and is selectable when designing the SMIP without loss of generality. When the composite analyte in solution is illuminated by UV light, a solution having a higher analyte concentration will exhibit a stronger fluorescence and vice versa, and fluorescence or luminance strength/ intensity can be used to determine concentration. The fluorescence or luminance strength/ intensity can be measured, for example, by a fluorescence spectrometer.

[0049] Similar solvatochromic characteristics and trends are observed in other SMIP+phthalate or SMIP+phthalate-based plasticizer composites. A similar trend or behaviour of solvatochromic characteristics that the peak intensity of the emitted light occurs at a relatively constant wavelength and the peak intensity generally increases with increased concentration of the target composite analyte is observed on other phthalates or phthalate-

based plasticizers such as DINP, DnOP-T, DMP, DEP, DEHP, BBP, DBP and other phthalates of table 3.

[0050] Figure 4B shows various intensity curves which are similar to that of Figure 4A, but in respect of DMP (Dimethyl phthalate), and with 2mg of SMIP chemosensors loaded in 3ml of ethanol. The descriptions relating to Figure 4A are incorporated herein by reference unless the context requires otherwise. The curves correspond to example concentrations of DMP at 0ppm, 5ppm, 10ppm, 20ppm, 30ppm, 50ppm, 70ppm, 100ppm, 150ppm, 200ppm, 300ppm, 500ppm, 700ppm, 1000ppm, 1500ppm, and 2000ppm, with the highest curve corresponding to light intensity characteristics of a target analyte when the concentration of DMP is 2,000ppm.

[0051] Figure 4C shows various intensity curves which are similar to that of Figures 4A and 4B, but in respect of DEP (Diethyl phthalate), and with 2mg of SMIP chemosensors loaded in 3ml of ethanol. The descriptions relating to Figures 4A and 4B are incorporated mutatis mutandis herein by reference unless the context requires otherwise. The curves correspond to example concentrations of the phthalate between 0ppm and 1000ppm, with corresponding concentration shown on a side of the curves, and with the highest curve corresponding to light intensity characteristics of a target analyte when the concentration of DEP is at 1,000ppm.

[0052] Figure 4D shows various intensity curves which are similar to that of Figures 4A and 4B, but in respect of DBP (Dibutyl phthalate), and with 2mg of SMIP chemosensors loaded in 3ml of ethanol. The descriptions relating to Figures 4A and 4B are incorporated mutatis mutandis herein by reference unless the context requires otherwise. The curves correspond to example concentrations of the phthalate between 0ppm and 1000ppm, with corresponding concentration shown on a side of the curves, and with the highest curve corresponding to light intensity characteristics of a target analyte when the concentration of DBP is at 1,000ppm.

Figure 4E shows various intensity curves which are similar to that of Figures 4A and 4B, but in respect of DNOP (Dioctyl phthalate), and with 2mg of SMIP chemosensors loaded in 3ml of ethanol. The descriptions relating to Figures 4A and 4B are incorporated mutatis mutandis herein by reference unless the context requires otherwise. The curves correspond to example concentrations of the phthalate between 0ppm and 2000ppm, with corresponding concentration shown on a side of the curves, and with the highest curve corresponding to light intensity characteristics of a target analyte when the concentration of DBP is at 2,000ppm.

[0053] Figure 4F shows various intensity curves which are similar to that of Figures 4A and 4B, but in respect of DIDP (Diisodecyl phthalate), and with 2mg of SMIP chemosensors loaded in 3ml of ethanol. The descriptions relating to Figures 4A and 4B are incorporated mutatis mutandis herein by reference unless the context requires otherwise. The curves correspond to example concentrations of the phthalate between 0ppm and 2000ppm, with corresponding

concentration shown on a side of the curves, and with the highest curve corresponding to light intensity characteristics of a target analyte when the concentration of DBP is at 2,000ppm.

[0054] Figure 4G shows various intensity curves which are similar to that of Figures 4A and 4B, but in respect of DEHP (Di (2-ethylhexyl) phthalate), and with 2mg of SMIP chemosensors loaded in 3ml of ethanol. The descriptions relating to Figures 4A and 4B are incorporated mutatis mutandis herein by reference unless the context requires otherwise. The curves correspond to example concentrations of the phthalate between 0ppm and 2mM, with corresponding concentration shown on a side of the curves, and with the highest curve corresponding to light intensity characteristics of a target analyte when the concentration of DBP is at 2mM.

[0055] Figure 4H shows various intensity curves which are similar to that of Figures 4A and 4B, but in respect of DNHP (Dihexyl phthalate), and with 2mg of SMIP chemosensors loaded in 3ml of ethanol. The descriptions relating to Figures 4A and 4B are incorporated mutatis mutandis herein by reference unless the context requires otherwise. The curves correspond to example concentrations of the phthalate between 0ppm and 2000ppm, with corresponding concentration shown on a side of the curves, and with the highest curve corresponding to light intensity characteristics of a target analyte when the concentration of DBP is at 2,000ppm.

[0056] Figure 4I shows various intensity curves which are similar to that of Figures 4A and 4B, but in respect of DINP (Diisononyl phthalate), and with 2mg of SMIP chemosensors loaded in 3ml of ethanol. The descriptions relating to Figures 4A and 4B are incorporated mutatis mutandis herein by reference unless the context requires otherwise. The curves correspond to example concentrations of the phthalate between 0ppm and 2000ppm, with corresponding concentration shown on a side of the curves, and with the highest curve corresponding to light intensity characteristics of a target analyte when the concentration of DBP is at 2,000ppm.

[0057] Figure 4J shows various intensity curves which are similar to that of Figures 4A and 4B, but in respect of BBP (Benzyl butyl phthalate), and with 2mg of SMIP chemosensors loaded in 3ml of ethanol. The descriptions relating to Figures 4A and 4B are incorporated mutatis mutandis herein by reference unless the context requires otherwise. The curves correspond to example concentrations of the phthalate between 0ppm and 2000ppm, with corresponding concentration shown on a side of the curves, and with the highest curve corresponding to light intensity characteristics of a target analyte when the concentration of DBP is at 2,000ppm.

[0058] The relationship between light emission intensity and target composite analyte concentrations for different types of SMIP+phthalate or SMIP+phthalate-based plasticizer composites are shown in Figures 5A and 5B.

[0059] Referring to Figures 5A and 5B, the target composite analytes (the DnOP+SMIPcomposite) in ethanol are subject to UV light excitation at 400nm, intensity of fluorescent responsive light at 500nm is measured and set out on the Y-axis and concentration of the target composite analytes (in ppm) is set out in the X-axis. The intensity values on the Y-axis are relative values with the emission intensity at zero concentration taken as unity reference. As shown in Figures 5A and 5B, it is noted that the responsive light emission intensity increases with increased target composite analytes concentration in ethanol. Light intensity is measured, for example, by measurement of photo-current output of the optical sensor. The data of Figures 5A and 5B are obtained by loading 2 mg of MIP powder in 3ml of ethanol and responsive light emission measurements are taken after 16 hours of loading the target composite analyte in the solvent ethanol.

[0060] In addition to the emission of fluorescent light in response to an excitation light, it is observed that the frequency of the fluorescent responsive light also changes, albeit slightly, with changes in target composite analyte concentration. As shown in Figure 4A, the emission light peaks shifts slightly towards increasing or higher wavelength with increasing concentration.

[0061] Furthermore, visible fluorescence colour change is also observable by the naked eye when concentration of target composite analyte increases from zero. For example, SMIP-DEHP probe in ethanol changes colour from magenta to yellow and the fluorescent responsive light changes colour from purple to cyan when concentration of the target composite analyte, that is, SMIP-DEHP increases from zero.

[0062] While ethanol is used as an example solvent, it should be appreciated that other organic solvents such as DMSO, DMF, methanol, ethanol, *iso*-propanol, THF, acetone, acetonitrile, dichloromethane, chloroform, ethyl acetate, water, and etc. are also suitable solvents for carrying SMIP-plasticizer probes.

[0063] The relationships or correlation between responsive light emission intensity and concentration of the target composite analyte were studied and utilised to devise schemes and apparatus for plasticizer detection.

[0064] For example, a portion of the solvatochromic properties of the target composite analyte of SMIP-DnOp of Figure 5A in the concentration range of between 0 and 1200 ppm is shown in Figure 6A. Referring to Figure 6A, five data points corresponding to concentrations of 200, 400, 600, 800 and 1000 ppm are plotted. The five data points are distributed substantially about a straight line having the equation $Y=0.0004X+0.9284$ (equation 1), where Y is intensity ratio (I_x/I_0), X is concentration in ppm, I_x is the emission light intensity at concentration X and I_0 is the emission light intensity at zero concentration. It is noted that the

data points have a R^2 (R square) value of 0.9883, where R is the Pearson correlation coefficient which means that the data points fit very well with the linear equation. Corresponding experimental results are tabulated in table 3 below.

[0065]

Prepared Conc., ppm	Intensity in trial 1	Intensity in trial 2	Average Intensity	Ratio	Calculated Conc., ppm
0	22130300	22079100	22104700	1	
200	22370000	22343100	22356550	1.011394	207.4838
400	24061000	24368200	24214600	1.09545	417.6257
600	26263300	26183200	26183200	1.184508	640.2707

5 Table 4

[0066] Example utilization of the correlation between optical properties such as fluorescent light emission intensity and concentration of target composite analytes for determination and/or detection of the presence and/or concentration of phthalates and phthalate-based plasticizers are described in the present disclosure.

- 10 [0067] Referring to Figure 3 for example, a plurality of SMIP probes is deposited on the transparent plastic card to form a card-shaped SMIP probe carrier or an SMIP detector. The SMIP probes are distributed at selected probe locations on a matrix of 10 rows and 10 columns. The probe locations are selected such that adjacent probes are spaced by at least one empty cell of the matrix to enhance visibility. Each of the SMIP probe is for a specific target analyte.
- 15 For example, cell 3,3 is an SMIP probe for capturing BBP (SMIP_BBP probe), cell 3,7 is an SMIP probe for capturing DBP (SMIP_DBP probe), cell 5,4 is an SMIP probe for capturing DEHP (SMIP_DEHP probe), cell 5,8 is an SMIP probe for capturing DnOP (SMIP_DnOP probe), cell 7,2 is an SMIP probe for capturing DIDP ((SMIP_DIDP probe)), and cell 7,6 is an SMIP probe for capturing DINP (SMIP_DINP probe). With such a multiple probe carrier, the
- 20 presence and concentration of a plurality of different target analytes and their specific types can be expediently determined using the detection apparatus 100.

[0068] Each of the six selected probe locations is deposited with a predetermined quantity of the specific SMIP probe (or reagent) to facilitate quantitative and/or qualitative measurements. In the example, each target probe location is square in shape and having an area of 1mm x

25 1mm and the totality of the target locations is a probe region 64 delineated in a circular region having a diameter of 10mmx10mm.

[0069] To calibrate the detection apparatus 100, calibration samples having selected and known target composite analyte concentrations on the sample-carrying card are placed inside the sample receptacle. Optical measurements are performed and calibration readings are obtained and stored. The calibration readings are then utilised by the processor to determine concentration of actual samples on a subsequently inserted target composite analyte carrying sample carrier. For example, where the calibration data are inside a substantially linear correlation region similar to that of Figure 6A, a linear relationship similar to equation 1 can be used to determine concentration of target composite analyte where the concentration is not at one of the calibration data points. Where the calibration data are not in a linear region, a best fit curve may be used for determination of target composite analyte where the concentration is not at one of the calibration data points. The calibration may be taken by measurement of output currents of the optical sensor at selected calibration data points and accuracy will be enhanced with an increased number of calibration data points. In addition, calibration data points may be selected to be at, around and/or above selected concentration limits to provide qualitative information on whether a threshold limit has been reached, not reached or exceeded. After calibration data of light intensity versus target composite analyte concentration have been obtained and stored, the process upon execution of pre-stored instructions would operate to determine whether concentration of a target composite analyte or a plurality of target composite analytes is at a specific concentration, below a threshold limit, or above a threshold limit without loss of generality. To facilitate quantitative analyses and calibration, each target probe is to fully react with a predetermined amount or volume of target analytes. For example, a target composite analyte of a predetermined weight is dissolved in a solvent of a predetermined weight to form a calibration sample of a predetermined concentration. For example, calibration samples of 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 40, 60, 80, 100, 200, 400, 600, 800, and 1000 ppm etc., may be used.

[0070] For example, calibration samples having predetermined concentration in a solution of a predetermined volume, say 3ml, may be used for calibration.

[0071] In evaluation applications, a sample of a determined weight in the predetermined volume of solution is to react thoroughly with a specific probe and the processor would then operate to determine concentration of a target composite analyte or a plurality of a target composite analytes according to the pre-stored and extrapolated solvatochromic correlation between light intensity and concentration.

[0072] During calibration operations, calibration samples carried on a sample-carrying card is received inside the sample receptacle. When the apparatus is set to operate in a calibration mode, the processor will cause the optical source to turn on to emit a source light (say, at 400nm) towards calibration samples on the sample carrier, and measure intensity of the

responsive light (say, of 500nm) which is emitted by the calibration sample in response to excitation by the source light. By recording intensity of the received responsive lights of the various calibration samples, for example, as represented by output current of the optical sensor, calibration data points are obtained and stored in a storage device such as a non-volatile memory on the apparatus. The processor will then execute stored instructions to identity a best fit line or a best fit curve according to the calibration data points, and then establish a correlation between received responsive light intensity and target composite analyte concentration. The correlation is then stored for use during evaluation applications. To provide specific calibration to specific target locations, a corresponding plurality of optical sensors is disposed to received light from the corresponding plurality of specific target locations without loss of generality.

[0073] With the calibration process, relationships between concentrations of a target organic compound and intensity of light at a selected wavelength, selected wavelengths, and/or a range of wavelengths are established for subsequent use in detection and quantitative analyses. During the calibration process, the processor will operate to correlate the light intensity measured, concentrations of the target organic compound in the target analyte solution, and concentrations of the target organic compound in the target material to form and store a calibration data or curves for subsequent detection use. The intensity of light being measured in the examples is intensity of light emitted by the target analyte solution in response to the excitation source light in the UV spectrum, and more specifically, at a selected UV wavelength, e.g., from 270nm to 420nm, including UV at 280nm, 315nm, 350nm, 385nm or 400nm or any range or ranges between the aforesaid wavelengths. In some embodiments or in combination, the intensity measurement can be transmissivity and/or reflectivity measurements without loss of generality.

[0074] During detection mode, a sample-carrying card carrying a plurality of field samples is received inside the sample receptacle. The apparatus is set to operate in a detection mode, and the processor will operate the optical source to emit the source light towards the field samples on the sample carrier, and measure intensity of the responsive light which is emitted by the field samples in response to excitation by the source light. By correlating the measured intensity with the measured intensity versus concentration relationships obtained in the calibration process, the concentration of the target organic compound in a target material can be determined.

[0075] To prepare field samples, a predetermined weight of target analyte (say DEHP) is dissolved in a predetermined weight or volume (say 3ml) of a prescribed solvent (say ethanol).

The solution comprising the target analyte is then applied to the SMIP detector so that the target analyte is to react thoroughly (say for 30 minutes) with the SMIP probe or probes on the

SMIP detector. The SMIP detector will be placed inside the sample receptacle of the detection apparatus after thorough reaction in order to determine concentration of a target analyte (say DEHP) through use of a target composite analyte (say SMIP-DEHP).

[0076] As example calibration curve is shown in Figure 6B. The emission intensity is plotted against a predetermined concentration of DEHP. An empirical relationship between the emission intensity and the concentration of DEHP is obtained using linear regression analysis. The calibration curve provides a simple and reliable way to calculate the uncertain concentration of DEHP from the emission intensity measured.

[0077] An example detector 70 has a sample carrier comprising one microfluidic capillary device or a plurality of microfluidic capillary devices as depicted in Figure 7. The sample carrier is of a cartridge type and comprises a transparent and UV-passing carrier housing having a base portion 72 extending in a longitudinal direction, a first side wall 74a extending upwardly from a first lateral side of the base portion and a second side wall 74b extending upwardly from a second lateral side of the base portion. A fluid inlet 76a and a fluid outlet 76b are defined on opposite longitudinal ends of the carrier housing. A plurality of microfluidic capillary devices each carrying a specific SMIP probe is disposed on the carrier housing intermediate the fluid inlet 76a and the fluid outlet 76b.

[0078] In the example of Figure 7, a total of 6 microfluidic capillary devices each carrying a specific SMIP probe is disposed laterally across the carrier housing so that the capillary members of the microfluidic capillary devices are substantially parallel to the longitudinal direction of the carrier housing to facilitate flow of liquid analyte across the microfluidic capillary devices in a direction substantially parallel to the longitudinal direction of the carrier housing. The microfluidic capillary devices are arranged such that an SMIP_DEHP probe is in abutment with the second side wall, with an SMIP_DnOP probe next to and in abutment with the SMIP_DEHP probe, further with an SMIP_DNIP probe next to and in abutment with the SMIP_DnOP probe, further with an SMIP_BBP probe next to and in abutment with the SMIP_DNIP probe, further with an SMIP_DBP probe next to and in abutment with the SMIP_BBP probe, and finally with an SMIP_DIDP probe intermediate and in abutment with the first sidewall 74a and the SMIP_DBP probe. When there is less than the prescribed number of probes, a probe of a larger width or a probe of the same width plus fillers to fill up the lateral space may be used without loss of generality. The microfluidic capillary devices comprise nano-scale SMIP net, which is made from polydimethylsiloxane (PDMS).

[0079] In this example, each of the SMIP probe has a width of 1mm, a height of 1mm and a length of 2 mm, defining a chamber volume of 2mm^3 for each probe. The entire sample carrier has a width of 6mm, length of 10mm and a height of 1mm.

[0080] In example use, liquid analyte is to enter the microfluidic capillary devices of the detector at the fluid inlet 76a and at 0.0005 mm³ per second and to leave the microfluidic capillary devices at 0.002 mm³ per second.

[0081] With the example detector 70, the optical arrangement will be arranged as depicted in Figure 8. As depicted in Figure 8, excitation light sources 86a1, 86a2 are disposed on two lateral sides of the carrier housing so that excitation light will be projected in a transversal direction orthogonal to the longitudinal direction and towards the microfluidic capillary devices. The optical sensor 16C is disposed above the microfluidic capillary devices for collection of response light which is orthogonal to the direction of illumination of the source lights 86a1, 86a2.

[0082] The detection apparatus to cooperate with detector 70 would include a liquid delivery arrangement, as depicted in Figure 9. The liquid delivery arrangement comprises a first pump which is to deliver liquid analytes to the inlet of the detector and a second pump which is to remove residual liquid from the outlet. Apart from the aforesaid specific modified arrangements, operation and other description above are applicable and the relevant description is incorporated herein. During operations, electromagnetic field is applied to attract superparamagnetic iron oxide (SPIO) nanoparticles materials which are attached to the target composite analytes and the resulting fluorescence intensity at a wavelength of 480nm to 510nm is measured to determine concentration.

[0083] An example detector 80 comprises a PDMS microfluidic capillary electrophoresis device, as depicted in Figure 10. Operation and properties of this detector 80 are depicted in Figure 11, and the detection apparatus to cooperate with detector 80 would include a liquid delivery arrangement, as depicted in Figure 12. Apart from the aforesaid specific modified arrangements, operation and other description above are applicable and the relevant description is incorporated herein.

[0084] An example detector 90 comprises a transparent tube for receiving liquid analytes, as depicted in Figure 13. The corresponding optical arrangement and detection apparatus are depicted in Figures 13 and 14. Apart from the aforesaid specific modified arrangements, operation and other description above are applicable and the relevant description is incorporated herein.

[0085] An example field sample extraction apparatus comprising a heating station and a sample collection device is depicted in Figure 15. The heating station comprises a thermal block and heating elements for heating the thermal block. The thermal block is made of metal and one or a plurality of sample receptacles is formed inside the metal block. During operations, a sample collector containing a sample, for example, a field collected sample is

received and seated inside the sample receptacles and the heating elements will heat up the collected sample to a prescribed temperature for a prescribed time set by an operator. The field collected sample may be heated at high temperature under sealed conditions for more expedited and efficient extraction. For example, the collected sample may be heated at, say
5 between 180° C and 200° C, for say 15-30 mins. In some embodiments, the heating elements may be processor controlled for better operational control and accuracy.

[0086] In an example sample extraction operation, a random sample of a known or predetermined weight (say 100mg) is taken and placed inside a sample collection container (say a glass tube) containing a predetermined weight (say 5mg) of solvent (say ethanol) and
10 subject to heating for target analyte extraction. The extracted analyte solution can then be used for analyses.

[0087] In an example sample extraction operation, a random sample of a known or predetermined weight (say 100mg) is taken and placed inside a sample collector. The sample collector comprises a lower container (which in this example is a glass tube such as a cuvette
15 tube having a tightly fitted fluid connector at its upper end, as depicted in Figure 16a. The sample collector is sealed by a sealing cap to form a "pressure-assisted solvent extraction tube", and the sample containing sample collector is then transferred to the sample extraction apparatus for heated analyte extraction while sealed so that pressure inside the container will increase due to heating. When a plasticizer containing sample is heated under sealed and
20 pressurized conditions, that is, using "pressure-assisted solvent extraction method", the rate of analyte extraction will be increased. When vaporization of analyte begins to occur, the sealing cap is removed and an upper container (which in this example is a glass tube such as a cuvette tube) having its open end facing the lower container is attached to the upper end of the fluid connector and to the lower container, as depicted in Figure 16b. With continued
25 heating, target analytes will be fully vaporized and move upwards through a passageway defined in the connector and deposited at an upper closed end or a peripheral wall adjacent the upper closed end of the upper container. The connector is tightly fitted to both the lower and upper containers and a passageway is formed in the connector so that the lower and upper containers are fluid communicable only through an aperture on the connector defining
30 the passage way.

[0088] After a prescribed time, which would be a time (say 1 minute) such that all target plasticizer analytes are expected to be fully vaporised and deposited into the upper container, the upper container will be detached from the lower container and the connector and the upper container is filled with a predetermined amount of solvent, say 3ml of ethanol. The extracted
35 sample is then ready for qualitative and/or quantitative analyses as described herein.

[0089] In applications where the sample does not fully move into the upper container, the upper container and/or the lower container will be re-weighted after completion of process to determine the actual amount of target materials that have moved into the upper container to prepare for quantitative analyses.

5 [0090] With the present sample extraction arrangement, samples can be extracted expeditiously and substantially hassle free.

[0091] In another example, the extraction method to prepare for qualitative and quantitative analysis is as follows:

- mixing 5ml ethanol with 100mg sample in lower container or vessel;
- 10 - inserting the lower container into a thermally controlled cavity defined in a thermal block of the sample extraction apparatus,
- fitting a connector to the upper free end of the lower container and then fitting the free end of the upper container to the connector,
- turning on the sample extraction apparatus to heat the sample inside the lower
15 container to 140° C for 30 minutes,
- removing the upper container after 30 minutes of heating and turning the upper container upside down so that its free end is facing upwards, and
- fill the upper container with 3ml of ethanol.

[0092] Where the target analyte is to be evaluated while in liquid form, a predetermined weight
20 (say 20mg) of SMIP probe is to be applied to the solution comprising ethanol and the target analyte. The resultant mixture is then subject to qualitative and/or quantitative analysed according to the disclosure.

[0093] Where the target analyte is to be evaluated using a solid state detector such as the detectors 60 and 70 herein, a predetermined weight of the solution comprising ethanol and
25 the target analyte will be applied to the solid state detector.

[0094] Alternatively, the target samples are extracted by high energy laser direct heating, or by microwave heating (say, 15 mins).

[0095] While the present disclosure has been described with reference to example and example embodiments, it should be appreciated that the example and example embodiments
30 are to assist understanding and not meant or intended to be restrictive. For example, while plasticizers such as DINP, DnOP-T, DMP, DEP, DEHP, BBP, DBP are referred to herein, the present disclosure would apply to other phthalates or phthalate-based plasticizers as set out in Table 2 and in general without loss of generality.

Phthalate Name	Abbreviation	Structural formula	Molecular weight (g/mol)	CAS No.
Dimethyl phthalate	DMP	$C_6H_4(COOCH_3)_2$	194.18	131-11-3
Diethyl phthalate	DEP	$C_6H_4(COOC_2H_5)_2$	222.24	84-66-2
Diallyl phthalate	DAP	$C_6H_4(COOCH_2CH=CH_2)_2$	246.26	131-17-9
Di-n-propyl phthalate	DPP	$C_6H_4[COO(CH_2)_2CH_3]_2$	250.29	131-16-8
Di-n-butyl phthalate	DBP	$C_6H_4[COO(CH_2)_3CH_3]_2$	278.34	84-74-2
Diisobutyl phthalate	DIBP	$C_6H_4[COOCH_2CH(CH_3)_2]_2$	278.34	84-69-5
Butyl cyclohexyl phthalate	BCP	$CH_3(CH_2)_3OOC C_6H_4COOC_6H_{11}$	304.38	84-64-0
Di-n-pentyl phthalate	DNPP	$C_6H_4[COO(CH_2)_4CH_3]_2$	306.4	131-18-0
Dicyclohexyl phthalate	DCP	$C_6H_4[COOC_6H_{11}]_2$	330.42	84-61-7
Butyl benzyl phthalate	BBP	$CH_3(CH_2)_3OOC C_6H_4COOCH_2C_6H_5$	312.36	85-68-7
Di-n-hexyl phthalate	DNHP	$C_6H_4[COO(CH_2)_5CH_3]_2$	334.45	84-75-3
Diisohexyl phthalate	DIHxP	$C_6H_4[COO(CH_2)_3CH(CH_3)_2]_2$	334.45	146-50-9
Diisoheptyl phthalate	DIHpP	$C_6H_4[COO(CH_2)_4CH(CH_3)_2]_2$	362.5	41451-28-9
Butyl decyl phthalate	BDP	$CH_3(CH_2)_3OOC C_6H_4COO(CH_2)_9CH_3$	362.5	89-19-0
Di(2-ethylhexyl) phthalate	DEHP, DOP	$C_6H_4[COOCH_2CH(C_2H_5)(CH_2)_3CH_3]_2$	390.56	117-81-7
Di(n-octyl) phthalate	DNOP	$C_6H_4[COO(CH_2)_7CH_3]_2$	390.56	117-84-0
Diisooctyl phthalate	DIOP	$C_6H_4[COO(CH_2)_5CH(CH_3)_2]_2$	390.56	27554-26-3
n-Octyl n-decyl phthalate	ODP	$CH_3(CH_2)_7OOC C_6H_4COO(CH_2)_9CH_3$	418.61	119-07-3
Diisononyl phthalate	DINP	$C_6H_4[COO(CH_2)_6CH(CH_3)_2]_2$	418.61	28553-12-0
Di(2-propylheptyl) phthalate	DPHP	$C_6H_4[COOCH_2CH(CH_2CH_2CH_3)(CH_2)_4CH_3]_2$	446.66	53306-54-0
Diisodecyl phthalate	DIDP	$C_6H_4[COO(CH_2)_7CH(CH_3)_2]_2$	446.66	26761-40-0
Diundecyl phthalate	DUP	$C_6H_4[COO(CH_2)_{10}CH_3]_2$	474.72	3648-20-2
Diisoundecyl phthalate	DIUP	$C_6H_4[COO(CH_2)_8CH(CH_3)_2]_2$	474.72	85507-79-5
Ditridecyl phthalate	DTDP	$C_6H_4[COO(CH_2)_{12}CH_3]_2$	530.82	119-06-2
Diisotridecyl phthalate	DIUP	$C_6H_4[COO(CH_2)_{10}CH(CH_3)_2]_2$	530.82	68515-47-9

Table 3: phthalate and phthalate-based plasticizers

[0096] Further examples of organic compounds that can be detected according to the present disclosure, may include, for example, organic functional groups such as phthalate esters, AZO, phenol, DOTE (PVC stabilizer), amide, nitrobenzene cosmetic fragrance, phosphate etc. as shown herein and below, and other organic compounds in general without loss of generality.

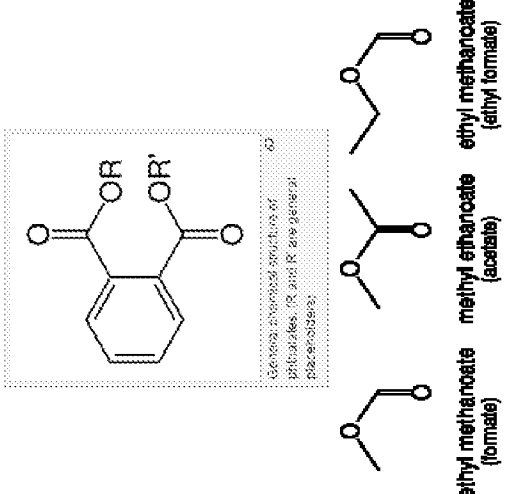
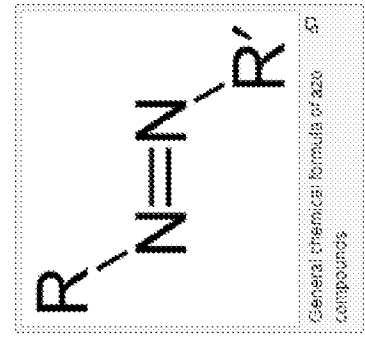
Organic Compound	Description	Chemical Structure of Functional Group	Example	EU	CAS
Phthalate Ester	Esters (R-CO-O-R') are named as alkyl derivatives of carboxylic acids. The alkyl (R') group is named first. The R-CO-O part is then named as a separate word based on the carboxylic acid name, with the ending changed from -oic acid to -oate. For example, CH ₃ CH ₂ CH ₂ CH ₂ COOCH ₃ is methyl pentanoate, and (CH ₃) ₂ CHCH ₂ CH ₂ COOCH ₂ CH ₃ is ethyl 4-methylpentanoate. For esters such as ethyl acetate (CH ₃ COOCH ₂ CH ₃), ethyl formate (HCOOCH ₂ CH ₃) or dimethyl phthalate that are based on common acids, IUPAC recommends use of these established names, called retained names. The -oate changes to -ate. Some simple examples, named both ways, are shown in the figure above.	 <p>General chemical structure of phthalates. (R and R' are general placeholders).</p> <p>methyl methanoate (formate) methyl ethanoate (acetate) ethyl methanoate (ethyl formate)</p>	See another table of 25 phthalates shown on Table 3		
Azo	Azo compounds are compounds bearing the functional group R-N=N-R', in which R and R' can be either aryl or alkyl. IUPAC defines azo compounds as: "Derivatives of diazene (diimide), HN=NH, wherein both hydrogens are substituted by hydrocarbyl groups, e.g. PhN=NPh azobenzene or diphenyldiazene." [1] The more stable derivatives contain two aryl groups. The N=N group is called an azo group. The name azo comes from azote, the French name for nitrogen that is derived from the Greek a (not) + zoe (to live)	 <p>General chemical formula of azo compounds</p>	Disodium 4-amino-3-[[4'-[(2,4-diaminophenyl)azo][1,1'-biphenyl]-4-yl]azo]-5-hydroxy-6-(phenylazo)naphthalene-2,7-disulphonate (C.I. Direct Black 38 Dye)	217-710-3	1937-37-7

Table 1A: Functional groups of organic compounds

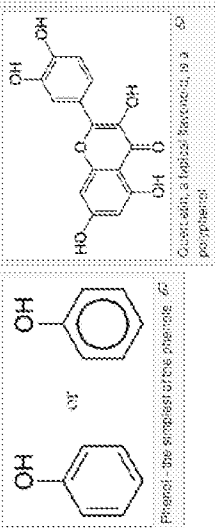
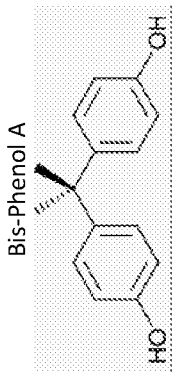
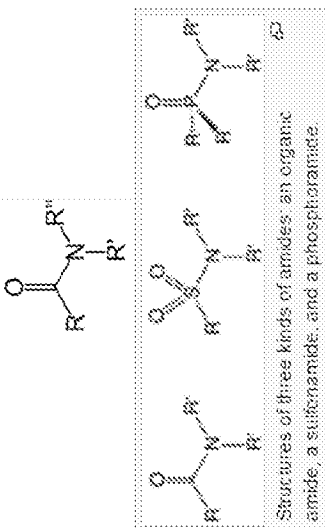
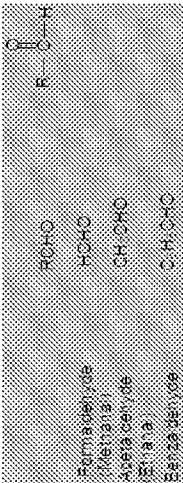
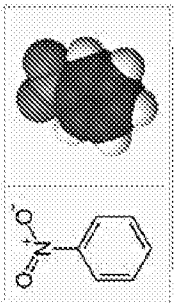
Organic Compound	Description	Chemical Structure of Functional Group	Example	EU	CAS
Phenol	It has an -OH group directly attached to a carbon of the aromatic ring (benzene)		 <p>Bis-Phenol A</p>	201-245-8	80-05-7
Amide	An amide functional group consists of a carbonyl group bonded to a nitrogen. In simple amides, two hydrogen atoms are bonded to the nitrogen (-CONH ₂) while in more complex amides, then nitrogen is bonded to one or two aliphatic or aromatic groups (-CONR).		<p>Formaldehyde, oligomeric reaction products with aniline: The group -CHO, represents an aldehyde. This does not mean the H is bonded to C and O, the correct structure is shown on the right.</p> 	500-036-1	25214-70-4
Nitrobenzene	Nitrobenzene is an organic compound with the chemical formula C ₆ H ₅ NO ₂ . It is a water-insoluble pale yellow oil with an almond-like odor. It freezes to give greenish-yellow crystals. It is produced on a large scale from benzene as a precursor to aniline. In the laboratory, it is occasionally used as a solvent, especially for electrophilic reagents.		Nitrobenzene	7416	98-95-3

Table 1B: Functional groups of organic compounds

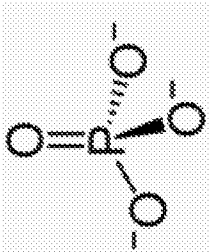
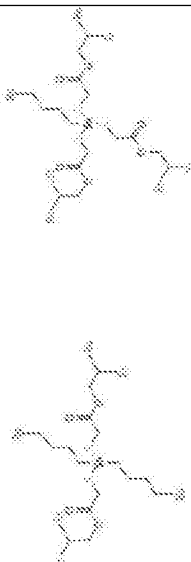
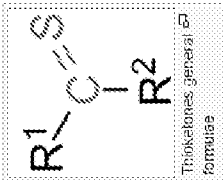
Organic Compound	Description	Chemical Structure of Functional Group	Example	EU	CAS
Phosphate	A phosphate (PO ₄ ³⁻) is an inorganic chemical and a salt of phosphoric acid. In organic chemistry, a phosphate, or organophosphate, is an ester of phosphoric acid. Of the various phosphoric acids and phosphates, organic phosphates are important in biochemistry and biogeochemistry (ecology), and inorganic phosphates are mined to obtain phosphorus for use in agriculture and industry. At elevated temperatures in the solid state, phosphates can condense to form pyrophosphates.		Tris(2-chloroethyl)phosphate	204-118-5	115-96-8
Thione	Thioketones (also known as thiones or thiocarbonyls) are organosulfur compounds related to conventional ketones. Instead of the formula R ₂ C=O, thioketones have the formula R ₂ C=S, which is reflected by the prefix "thio-" in the name of the functional group. Unhindered alkylthioketones typically tend to form polymers or rings. 2-ethylhexyl 10-ethyl-4,4-diethyl-7-oxo-8-oxa-3,5-dithia-4-stannatetradecanoate and 2-ethylhexyl 10-ethyl-4-[[2-[(2-ethylhexyl)oxy]-2-oxoethyl]thio]-4-octyl-7-oxo-8-oxa-3,5-dithia-4-stannatetradecanoate (reaction mass of DOTE and MOTE)	 <p>Figure 1: Structural formula of DOTE (left) and MOTE (right)</p> 	Imidazolidine-2-thione (2-imidazoline-2-thiol) (DOTE)	202-506-9	96-45-7

Table 1C: Functional groups of organic compounds

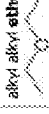
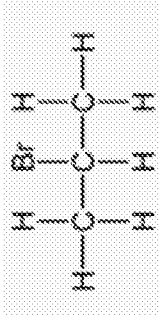
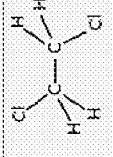
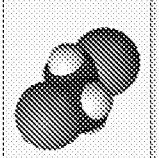
Organic Compound	Description	Chemical Structure of Functional Group	Example	EU	CAS
Ether	Ethers are a class of organic compounds that contain an ether group—an oxygen atom connected to two alkyl or aryl groups—of general formula $R-O-R'$. These ethers can again be classified into two varieties, if the alkyl groups are the same on both sides of the oxygen atom then it is a simple or symmetrical ether. Whereas if they are different the ethers are called mixed or unsymmetrical ethers[1] A typical example is the solvent and anesthetic diethyl ether, commonly referred to simply as "ether" ($CH_3-CH_2-O-CH_2-CH_3$). Ethers are common in organic chemistry and pervasive in biochemistry, as they are common linkages in carbohydrates and lignin.	  	1,2-bis(2-methoxyethoxy)ethane (TEGDME, triglyme)	203-977-3	112-49-2
1-bromopropane	Halogenation is a chemical reaction that involves the reaction of a compound with a halogen and results in the halogen being added to the compound. Organic compounds undergo halogenation much more readily than inorganic compounds. Dehalogenation is the reverse of halogenation and results in the removal of a halogen from a molecule.[1] The pathway and stoichiometry of halogenation depends on the structural features and functional groups of the organic substrate		1-bromopropane	203-445-0	106-94-5
1,2-Dichloroethane	1,2-dichloroethane (DCE) commonly known by its old name of ethylene dichloride (EDC), is a chlorinated hydrocarbon. The most common use of 1,2-dichloroethane is in the production of vinyl chloride which is used to make a variety of plastic and vinyl products including polyvinyl chloride (PVC) pipes, furniture and automobile upholstery, wall coverings, housewares, and automobile parts.[3] It is a colourless liquid with a chloroform-like odour. 1,2-Dichloroethane is also used generally as an intermediate for other organic chemical compounds and as a solvent. It forms azeotropes with many other solvents, including water (b.p. 70.5 °C) and other chlorocarbons.	 	1,2-Dichloroethane	203-458-1	107-06-2

Table 1D: Functional groups of organic compounds

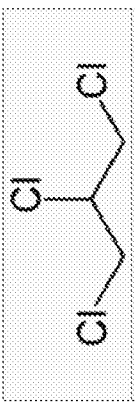
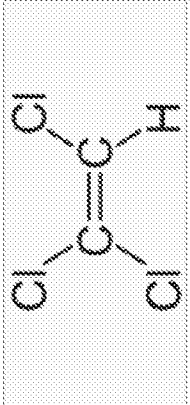
Organic Compound	Description	Chemical Structure of Functional Group	Example	EU	CAS
1,2,3-trichloropropane	1,2,3-Trichloropropane (TCP) is a chemical compound that is commonly used as an industrial solvent. Exposure by inhalation, skin contact, or ingestion can be harmful to health. 1,2,3-Trichloropropane can be produced via the chlorination of propylene. Other reported methods for producing 1,2,3-trichloropropane include the addition of chlorine to allyl chloride, reaction of thionyl chloride with glycerol, and the reaction of phosphorus pentachloride with either 1,3- or 2,3-dichloropropanol. TCP also may be produced as a byproduct of processes primarily used to produce chemicals such as dichloropropene (a soil fumigant), propylene chlorohydrin, propylene oxide, dichlorohydrin, and glycerol.	<p>1,2,3-Trichloropropane</p> 	1,2,3-trichloropropane	202-486-1	96-18-4
Trichloroethylene	Trichloroethylene (C ₂ HCl ₃) is a halocarbon commonly used as an industrial solvent. It is a clear non-flammable liquid with a sweet smell. It should not be confused with the similar 1,1,1-trichloroethane, which is commonly known as chloroethene. The IUPAC name is trichloroethene. Industrial abbreviations include TCE, trichlor, Trike, Tricky and tri. It has been sold under a variety of trade names. Under the trade names Trimar and Trilene, trichloroethylene was used as a volatile anesthetic and as an inhaled obstetrical analgesic in millions of patients.	<p>Trichloroethylene</p> 	Trichloroethylene	201-167-4	79-01-6

Table 1E: Functional groups of organic compounds

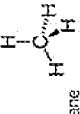
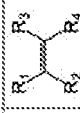
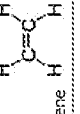
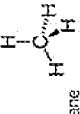
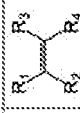
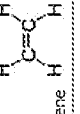
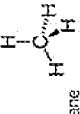
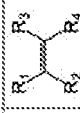
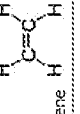
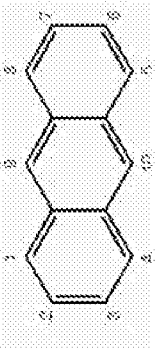
Organic Compound	Description	Chemical Structure of Functional Group	Example	EU	CAS																		
Alkanes	An alkane, or paraffin (a historical name that also has other meanings), is a saturated hydrocarbon. Alkanes consist only of hydrogen and carbon atoms and all bonds are single bonds. Alkanes (technically, always acyclic or open-chain compounds) have the general chemical formula C_nH_{2n+2} . For example, methane is CH_4 , in which $n=1$ (n being the number of carbon atoms). Alkanes belong to a homologous series of organic compounds in which the members differ by a molecular mass of 14.03u (mass of a methanediyl group, $-CH_2-$, one carbon atom of mass 12.01u, and two hydrogen atoms of mass $\approx 1.01u$ each). There are two main commercial sources: petroleum (crude oil) and natural gas.	<table border="1"> <tr> <td>Alkane*</td><td>Alkyl</td><td>RH</td><td></td><td>alkyl-</td><td></td></tr> <tr> <td>Alkene*</td><td>Alkenyl</td><td>$R_1R_2C=CR_3$</td><td></td><td>alkenyl-</td><td></td></tr> <tr> <td>Alkyne*</td><td>Alkynyl</td><td>$RC\equiv CR$</td><td>$R-C\equiv C-R$</td><td>alkynyl-</td><td></td></tr> </table>	Alkane*	Alkyl	RH		alkyl-		Alkene*	Alkenyl	$R_1R_2C=CR_3$		alkenyl-		Alkyne*	Alkynyl	$RC\equiv CR$	$R-C\equiv C-R$	alkynyl-		Alkanes, C10-13, chloro (Short Chain Chlorinated Paraffins)	287-476-5	85535-84-8
Alkane*	Alkyl	RH		alkyl-																			
Alkene*	Alkenyl	$R_1R_2C=CR_3$		alkenyl-																			
Alkyne*	Alkynyl	$RC\equiv CR$	$R-C\equiv C-R$	alkynyl-																			
PAHs	Standard line-angle schematic representation of an important PAH, benzo[a]pyrene, where carbon atoms are represented by the vertices of the hexagons, and hydrogens are inferred as projecting out at 120° angles to fill the fourth carbon valence	<p>Anthracene: Tricyclo[8.4.0.0^{3,8}]tetradeca-1,3,5,7,9,11,13-heptaene</p> 	Anthracene Functional Group	204-371-1	120-12-7																		

Table 1F: Functional groups of organic compounds

Organic Compound	Description	Chemical Structure of Functional Group	Example	EU	CAS																								
Amine	<p>Amines are organic compounds and functional groups that contain a basic nitrogen atom with a lone pair. Amines are derivatives of ammonia, wherein one or more hydrogen atoms have been replaced by a substituent such as an alkyl or aryl group. (These may respectively be called alkylamines and arylamines; amines in which both types of substituent are attached to one nitrogen atom may be called alkylarylamines.) Important amines include amino acids, biogenic amines, trimethylamine, and aniline; see Category:Amines for a list of amines. Inorganic derivatives of ammonia are also called amines, such as chloramine (NH₂Cl); see Category:Inorganic amines.</p> <p>Compounds with a nitrogen atom attached to a carbonyl group, thus having the structure R-CO-NR'R'', are called amides and have different chemical properties from amines.</p>	<table border="1"> <tr> <td>Primary amine</td><td>RNH₂</td><td></td><td>amino-</td><td></td><td>-amine</td></tr> <tr> <td>Secondary amine</td><td>R₂NH</td><td></td><td>amino-</td><td></td><td>-amine</td></tr> <tr> <td>Tertiary amine</td><td>R₃N</td><td></td><td>amino-</td><td></td><td>-amine</td></tr> <tr> <td>ammonium ion</td><td>R₄N⁺</td><td></td><td>ammonio-</td><td></td><td>-ammonium</td></tr> </table> <p>Amines</p>	Primary amine	RNH ₂		amino-		-amine	Secondary amine	R ₂ NH		amino-		-amine	Tertiary amine	R ₃ N		amino-		-amine	ammonium ion	R ₄ N ⁺		ammonio-		-ammonium	4-methyl-m-phenylenediamine (toluene-2,4-diamine)	202-453-1	95-80-7
Primary amine	RNH ₂		amino-		-amine																								
Secondary amine	R ₂ NH		amino-		-amine																								
Tertiary amine	R ₃ N		amino-		-amine																								
ammonium ion	R ₄ N ⁺		ammonio-		-ammonium																								

Table 1G: Functional groups of organic compounds

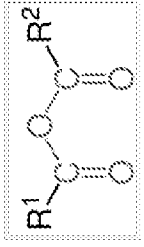
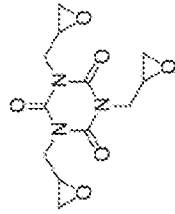
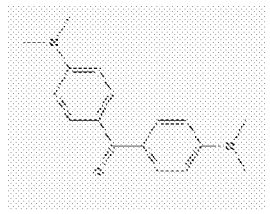
Organic Compound	Description	Chemical Structure of Functional Group	Example	EU	CAS
Anhydride	An acid anhydride is a compound that has two acyl groups bonded to the same oxygen atom. A common type of organic acid anhydride is a carboxylic anhydride, where the parent acid is a carboxylic acid, the formula of the anhydride being (RC(O)) ₂ O. Symmetrical acid anhydrides of this type are named by replacing the word acid in the name of the parent carboxylic acid by the word anhydride.[2] Thus, (CH ₃ CO) ₂ O is called acetic anhydride. Mixed (or unsymmetrical) acid anhydrides, such as acetic formic anhydride		Hexahydromethylphthalic anhydride [1], Hexahydro-4-methylphthalic anhydride [2], Hexahydro-1-methylphthalic anhydride [3], Hexahydro-3-methylphthalic anhydride [4] [The individual isomers [2], [3] and [4] (including their cis- and trans- stereo isomeric forms) and all possible combinations of the isomers [1] are covered by this entry]	247-094-1	25550-51-0 19438-60-9 48122-14-9 57110-29-9
TGIC	TGIC, in its molten state reacts easily with various functional groups in the presence of catalysts or promoters. TGIC, like other similar epoxides, can react with amines, carboxylic acids, carboxylic acid anhydrides, phenols and alcohols. In the actual curing process, these reactions are more complex because of their side reactions.		1,3,5-Tris(oxiran-2-ylmethyl)-1,3,5-triazinane-2,4,6-trione (TGIC)	219-514-3	2451-62-9
Michler	Michler's ketone is an organic compound with the formula of [(CH ₃) ₂ NC ₆ H ₄] ₂ CO. This electron-rich derivative of benzophenone is an intermediate in the production of dyes and pigments, for example Methyl violet. It is also used as a photosensitizer. The ketone is prepared today as it was originally by Michler using the Friedel-Crafts acylation of dimethylaniline (C ₆ H ₅ NMe ₂) using phosgene (COCl ₂) or equivalent reagents such as triphosgene (Me = methyl):[2] COCl ₂ + 2 C ₆ H ₅ NMe ₂ → (Me ₂ NC ₆ H ₄) ₂ CO + 2 HCl The related tetraethyl compound (Et ₂ NC ₆ H ₄) ₂ CO, also a precursor to dyes, is prepared similarly.		4,4'-bis(dimethylamino)-4''-(methylamino)trityl alcohol [with ≥ 0.1% of Michler's ketone (EC No. 202-027-5) or Michler's base (EC No. 202-959-2)]	209-218-2	561-41-1

Table 1H: Functional groups of organic compounds

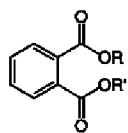
Claims

1. A method of detecting presence and/or determining concentration of a target organic compound in a sample, the method comprising:
 - dissolving a target sample in an organic solvent to obtain a sample solution,
 - 5 – applying a probing device to the sample solution to form a target analyte, the probing device comprising a solvatochromic molecularly imprinted polymer or SMIP, and the SMIP comprising a solvatochromic functional group or a solvatochromic functional monomer the colour and/or fluorescence properties of which will change upon coupling or encountering the target organic compound or
 - 10 – detecting or determining presence and/or concentration of the target organic compound with reference to colorimetric, luminescent and/or fluorescent response of the target analyte.
2. The method according to Claim 1, wherein the presence and/or concentration of the target organic compound is determined by applying an excitation optical signal to the target analyte and by measuring intensity of a responsive optical signal which is emitted by the target analyte in response, and/or wherein the intensity of the responsive optical signal being measured is the intensity of a selected wavelength or selected wavelengths, the selected wavelength being different to the wavelength of the excitation optical signal and the selected wavelengths comprises wavelengths which are different to the wavelength of the excitation optical signal.
3. A detection apparatus for detection of a target organic compound in a sample, wherein the apparatus comprises a sample receptacle for receiving a target analyte, an optical arrangement for emitting an excitation optical signal to the target analyte and for detecting a responsive optical signal which is emitted from the target analyte in response to the excitation optical signal, and a processor to determine qualitative and/or quantitative information of the target organic compound in the sample according to solvatochromic properties and/or with reference to colorimetric, luminescent and/or fluorescent response of the target analyte; wherein the target analyte comprises analyte composites and each analyte composite comprises a probing device and a target organic compound or at least a characteristic functional group thereof; wherein the probing device comprises a solvatochromic molecularly imprinted polymer or SMIP, and the SMIP comprises a solvatochromic functional group or a solvatochromic functional monomer the colour and/or fluorescence properties of which is to change upon encountering or coupling with the target organic compound.

4. The detection apparatus according to Claim 3, wherein the processor is to determine concentration of the target organic compound with reference to intensity of the responsive optical signal at a selected wavelength or selected wavelengths, the selected wavelength being different to the wavelength of the excitation optical signal and the selected wavelengths comprises wavelengths which are different to the wavelength of the excitation optical signal.
5. The detection apparatus according to claims 3 or 4, wherein the optical arrangement comprises an optical compartment and the sample receptacle is inside the optical arrangement, and wherein the optical source is to emit ultra-violet light towards the sample receptacle during operations.
6. A sample extraction apparatus for detection of an organic compound, the apparatus comprising a heating chamber and an enclosed sample container, the enclosed sample container having a bottom portion and an enclosed upper portion, wherein the heating chamber is for heating sample on the bottom portion for sample collection at the enclosed upper portion.
7. An organic compound sample extraction method to prepare for quantitative or concentration determination, the method comprising:
- placing a first predetermined weight of a target organic compound containing sample inside a sample container and closing the sample container to form an enclosed sample container, the enclosed sample container comprising a bottom portion, a top portion and an upper portion comprising an intermediate wall dependent from the top portion;
 - heating the bottom portion of the sample container to vaporize the organic compound to deposit on the top and/or upper portions of the enclosed sample container when the sample is on the bottom portion of the enclosed sample container; and
 - dissolving the organic compound from the sample container in a second predetermined amount of a polar organic solvent.
8. An organic compound sample extraction method according to Claim 7, wherein the polar organic solvent is ethanol; and/or the heating is performed at high temperature under sealed conditions.
9. The detection apparatus, the sample extraction apparatus, the organic compound sample extraction method or the detection method according to any preceding claim, wherein the target organic compound is a phthalate or a phthalate-based plasticizer, and/or comprises one or more than one of the functional groups of Tables 1A-1H, and/or

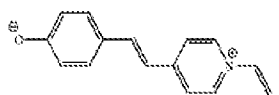
having solvatochromic-concentration properties of Figures 4A to 4I; and/or wherein the target phthalate or the phthalate-based plasticizer is any one of the phthalates identified in Table 3.

- 5 10. An organic compound detector, wherein the detector comprises a solvatochromic molecularly imprinted polymer SMIP, the SMIP comprising a solvatochromic functional group or a solvatochromic functional monomer the colour and/or fluorescence properties of which is to change upon coupling with or encountering the target organic compound.
- 10 11. The detector according to Claim 10, wherein the molecularly imprinted polymer comprises a receptor site for selective capture or selective attachment of the target organic compound and/or wherein the receptor site is for non-covalent interaction with the target organic compound to perform said selective capture.
- 15 12. The detector according to claims 10 or 11, wherein the molecularly imprinted polymer or SMIP is held on a solid-state substrate or is in a polar organic solvent; and/or wherein a plurality of N molecularly imprinted polymers is deposited on a corresponding plurality of target locations on the solid-state substrate, N being an integer larger than 1; and the N molecularly imprinted polymers is for detection of a corresponding plurality of N target organic compounds; and/or wherein the target locations are arranged in an array or a matrix comprising a plurality of arrays; and/or wherein the solid state substrate is transparent or translucent; and/or wherein the solid state substrate is in the form of a card or cartridge; and/or wherein the detector is in the form of a card or cartridge.
- 20 13. The detector according to any one of Claims 10-12, wherein the molecularly imprinted polymer or SMIP after capture of the target organic compound is to emit a fluorescent light of a second frequency when excited by a source light of a first frequency different to the second frequency; and/or wherein the source light is UV light; and/or wherein intensity of the fluorescent light correlates to concentration of the target organic compound.
- 25 14. The detector according to any one of Claims 10-13, wherein the molecularly imprinted polymer or SMIP is for capturing an organic compound comprising one or more than one functional group as shown in Tables 1A-1H; and/or wherein the molecularly imprinted polymer is affinitive or complementary to a target phthalate or a phthalate-based plasticizer.
- 30 15. The detector according to Claim 14, wherein the target phthalate or the phthalate-based plasticizer comprises the functional group:



; and/or wherein the target phthalate or the phthalate-based plasticizer is any one of the phthalates identified in Table 3.

16. The detector according to any one of Claims 10-15, wherein the molecular imprinted polymer comprises a solvatochromic functional monomer having the structure:



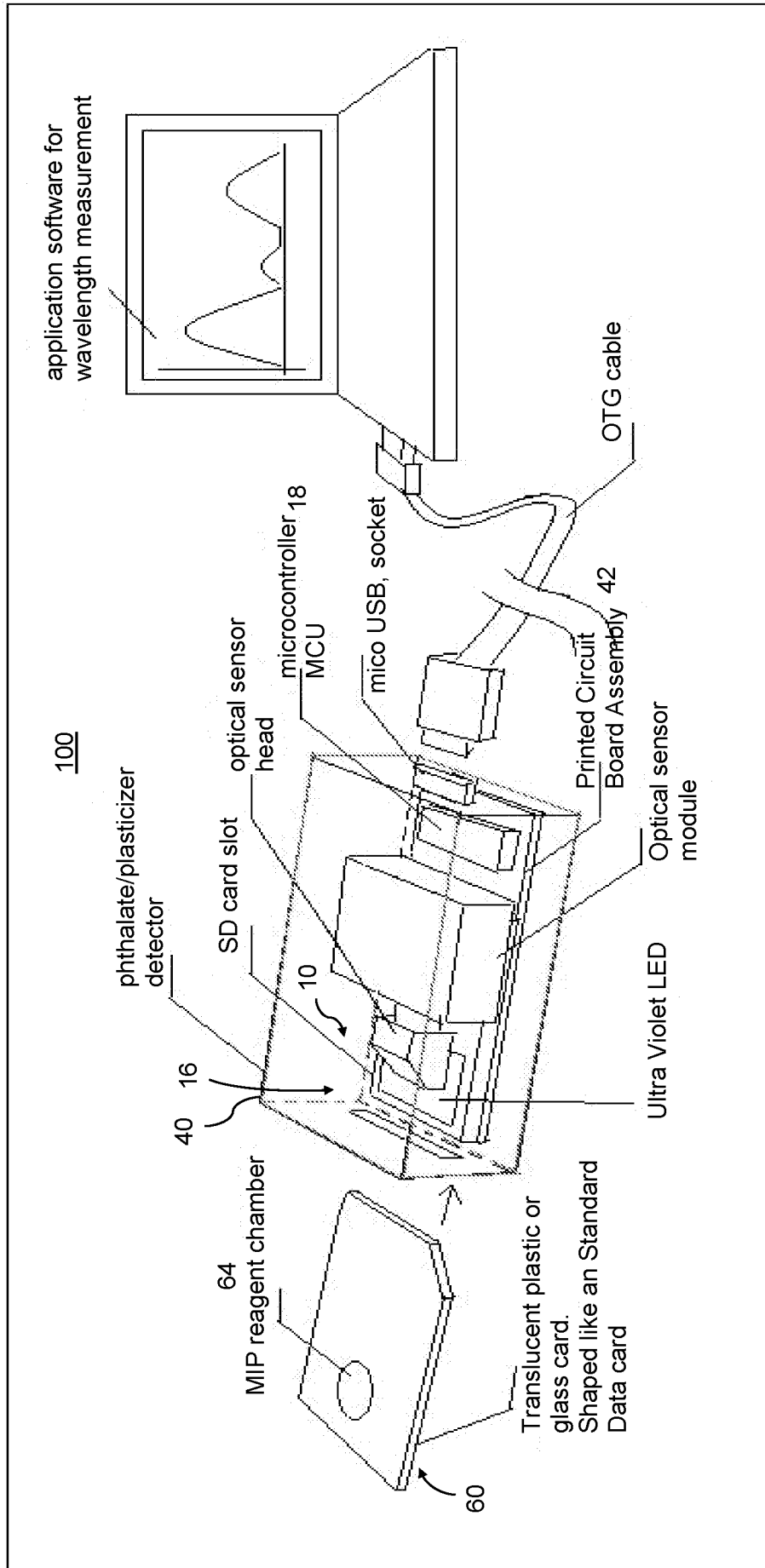


Fig. 1

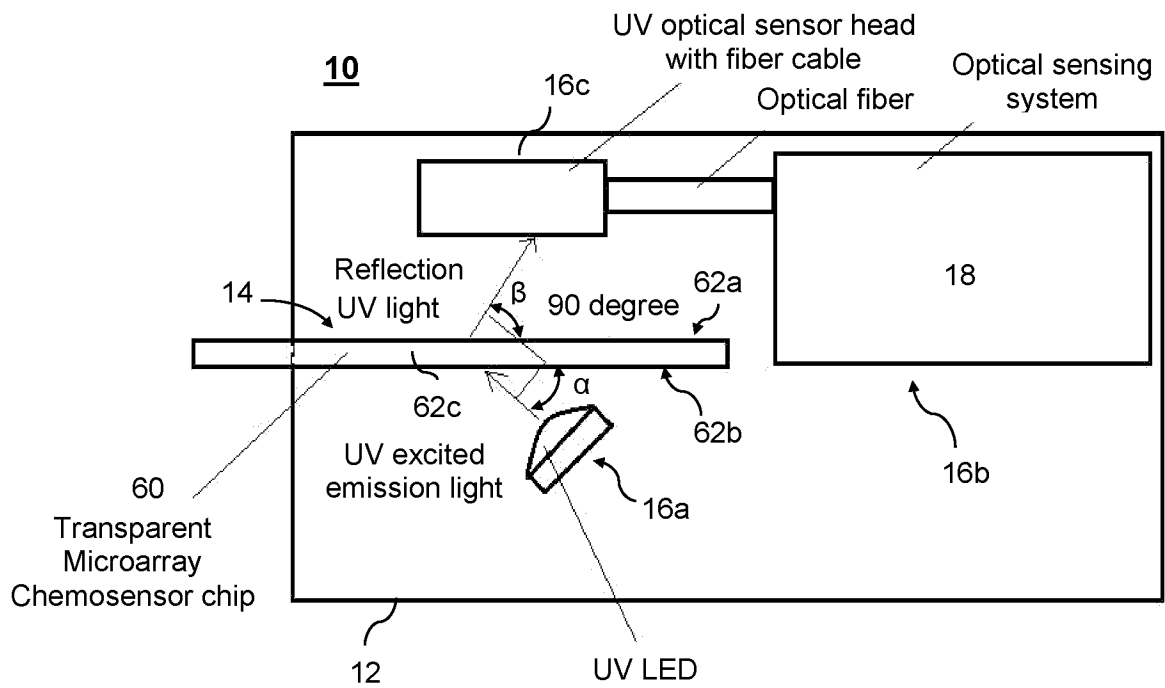


Fig. 2

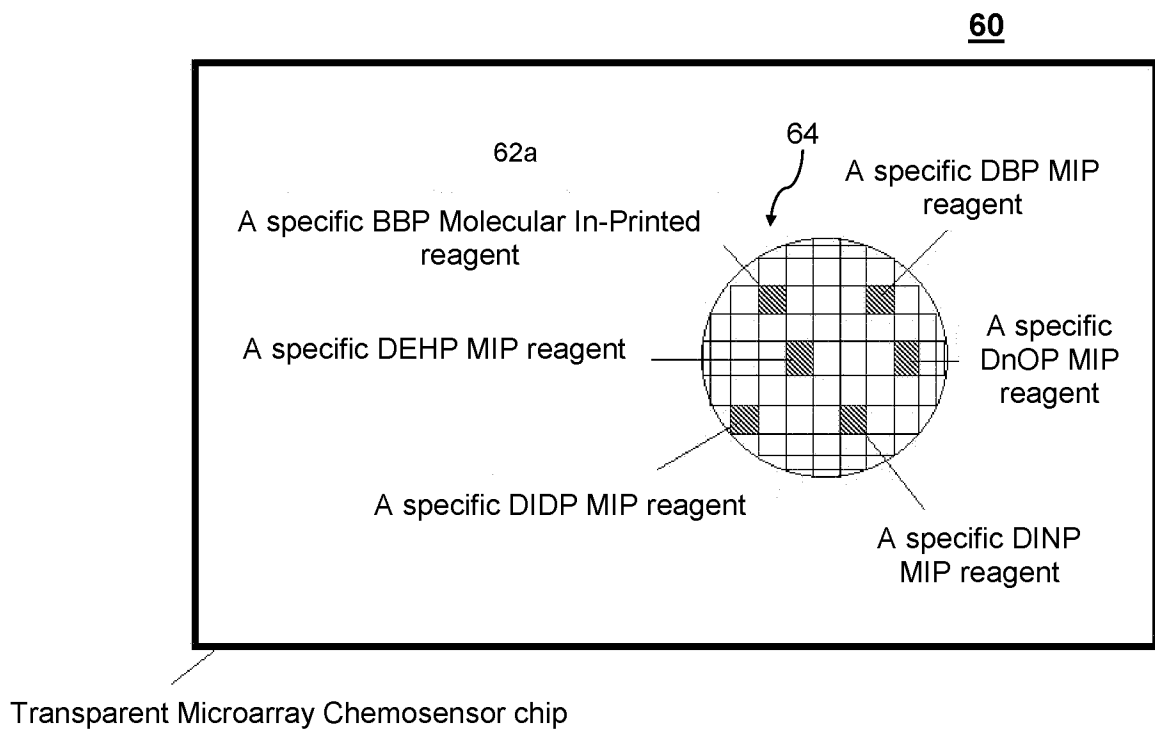


Fig. 3

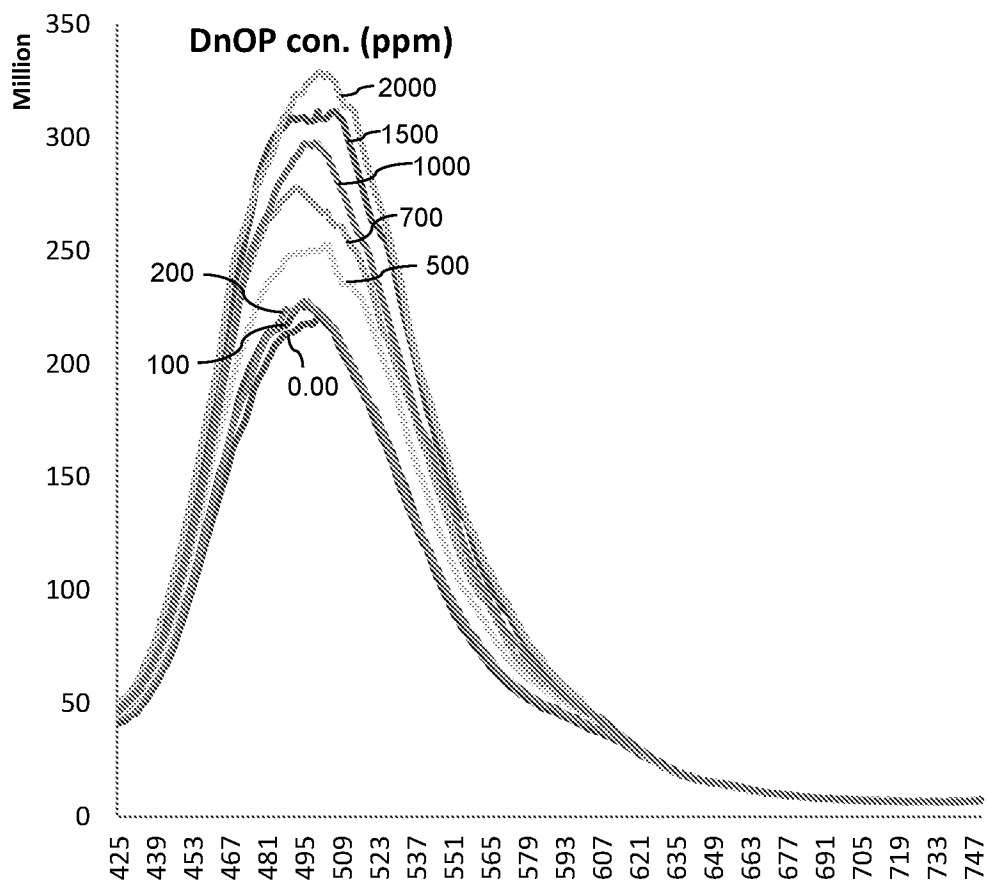


Fig. 4A

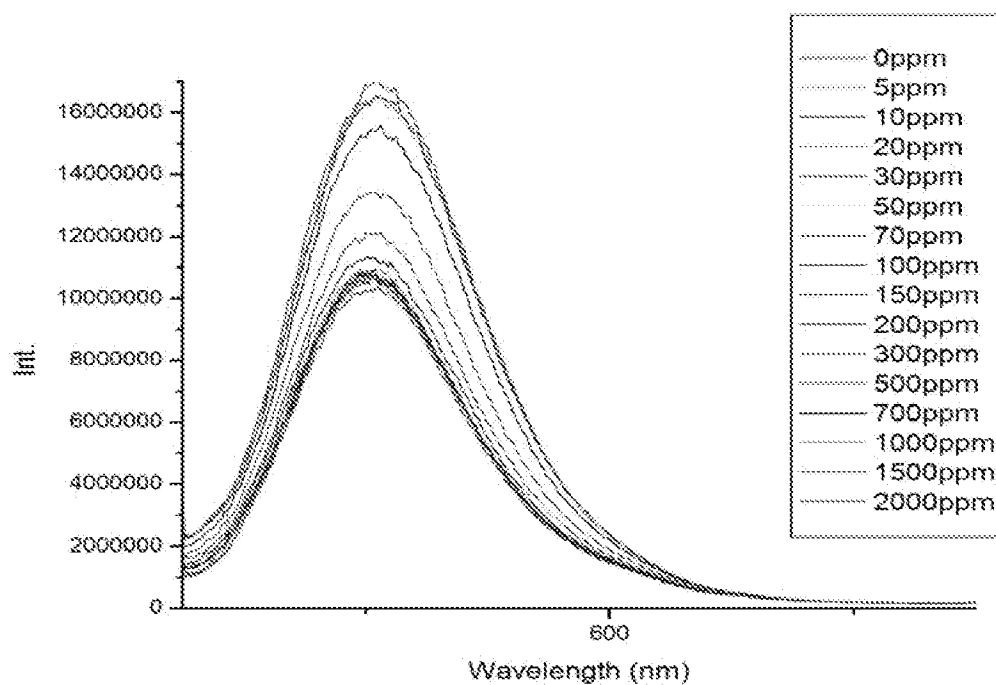


Fig. 4B

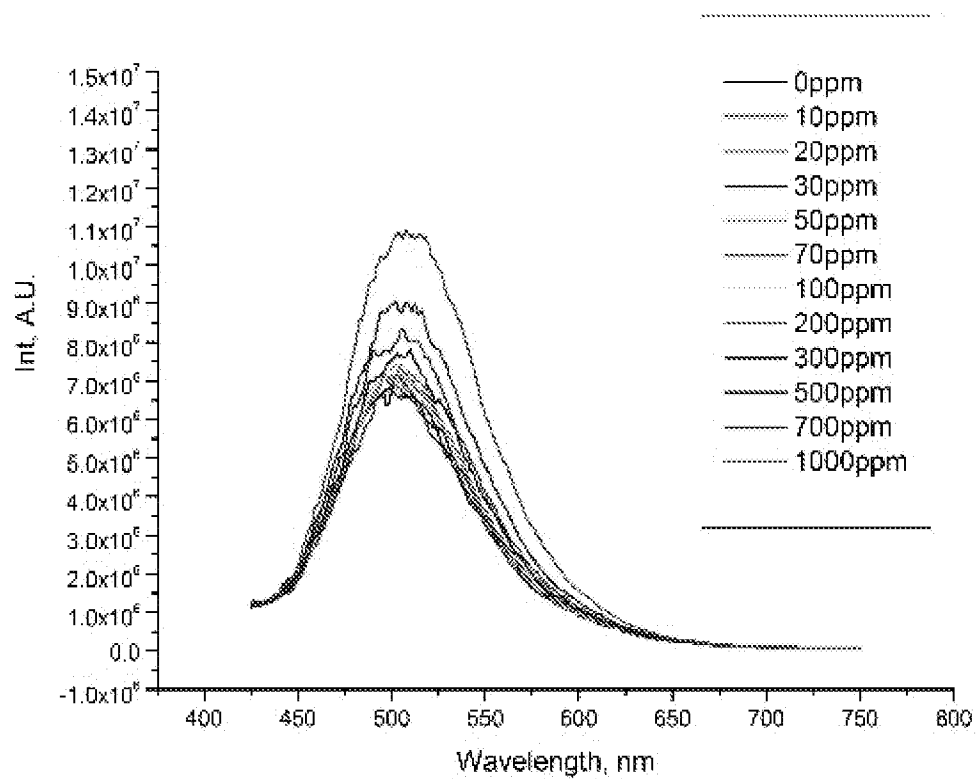


Fig. 4C

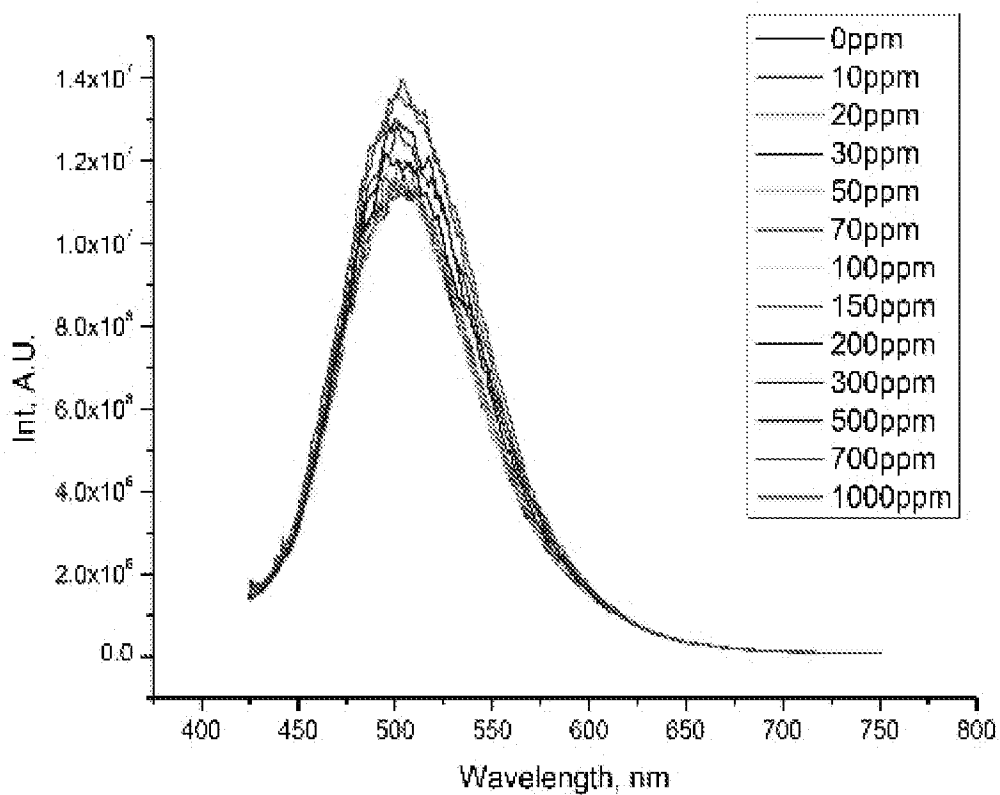


Fig. 4D

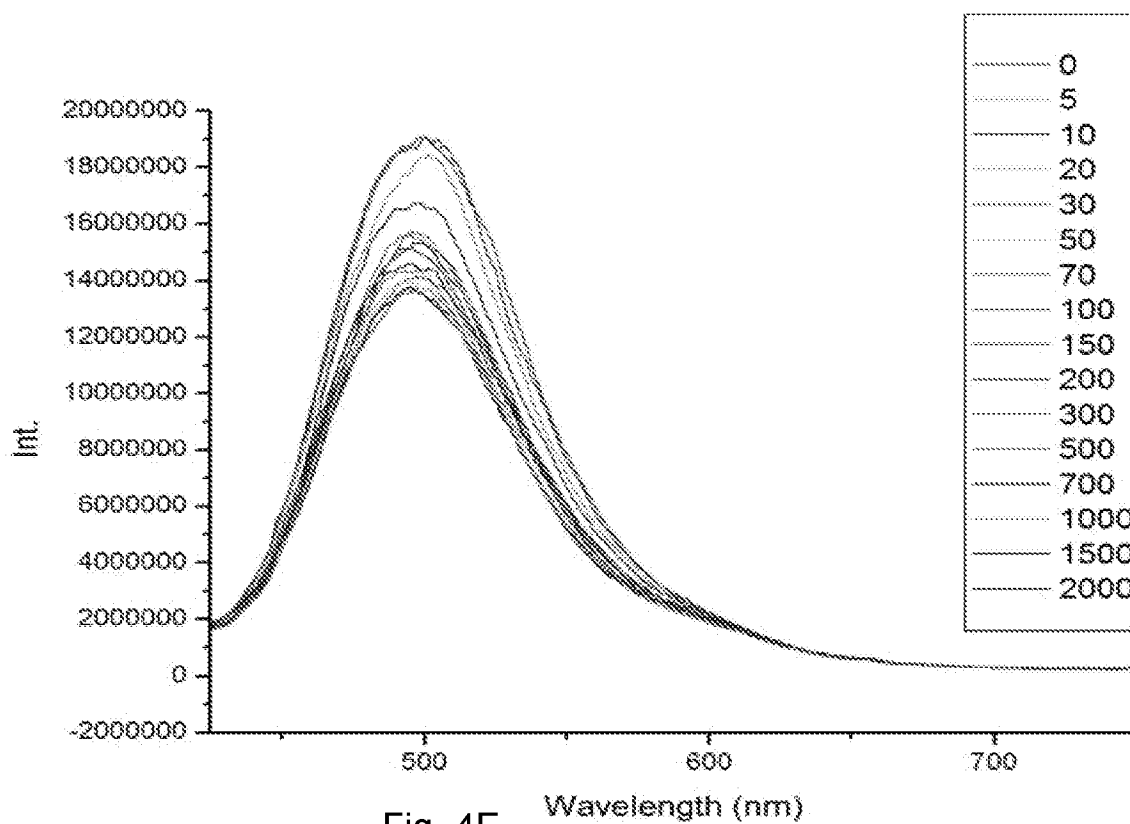


Fig. 4E

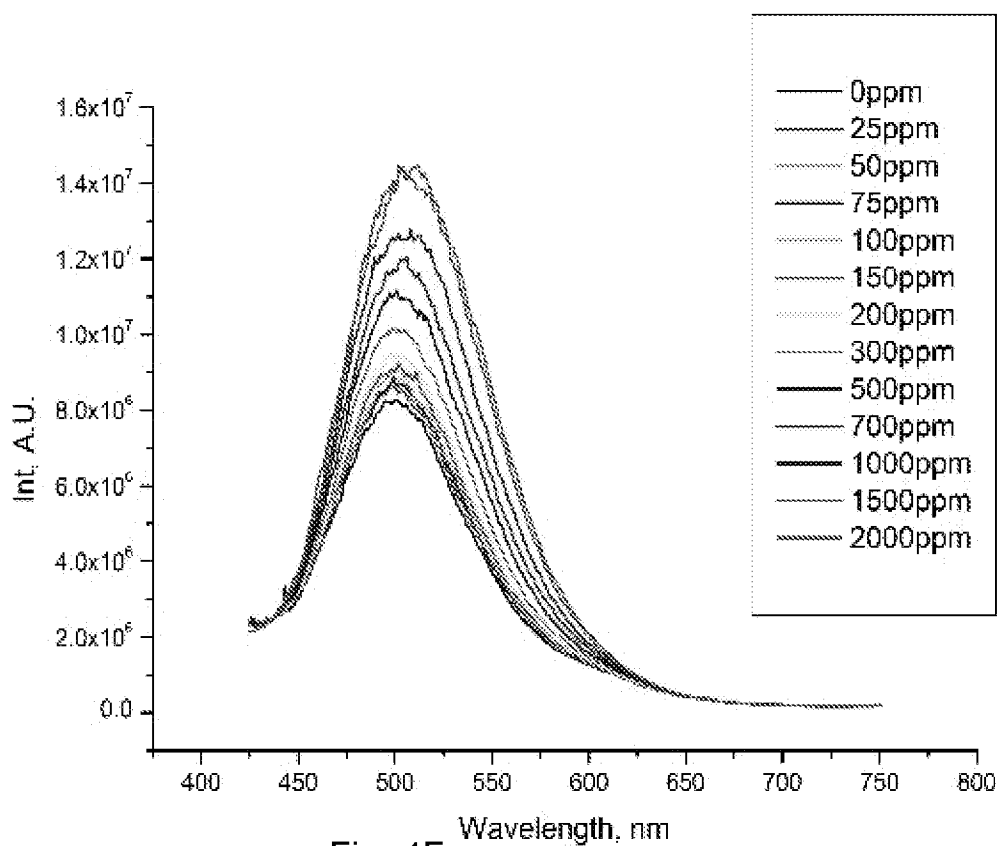


Fig. 4F

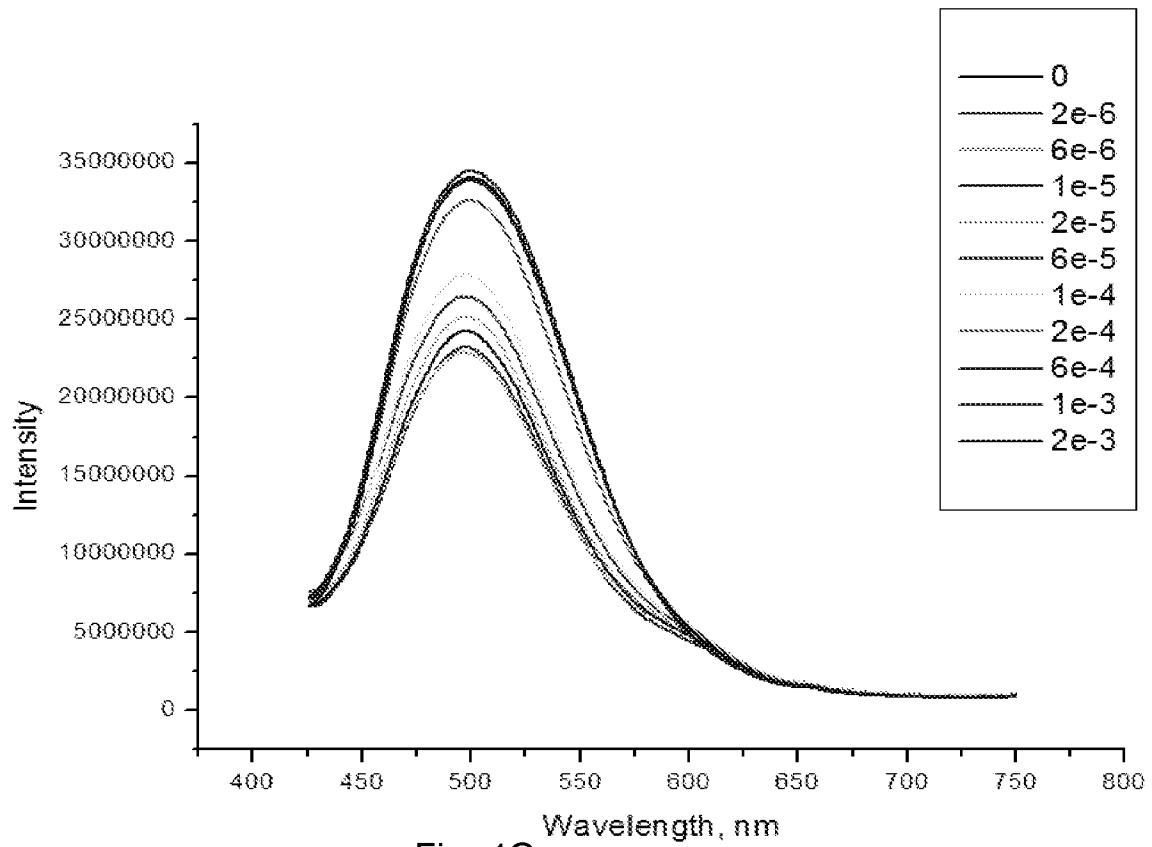


Fig. 4G

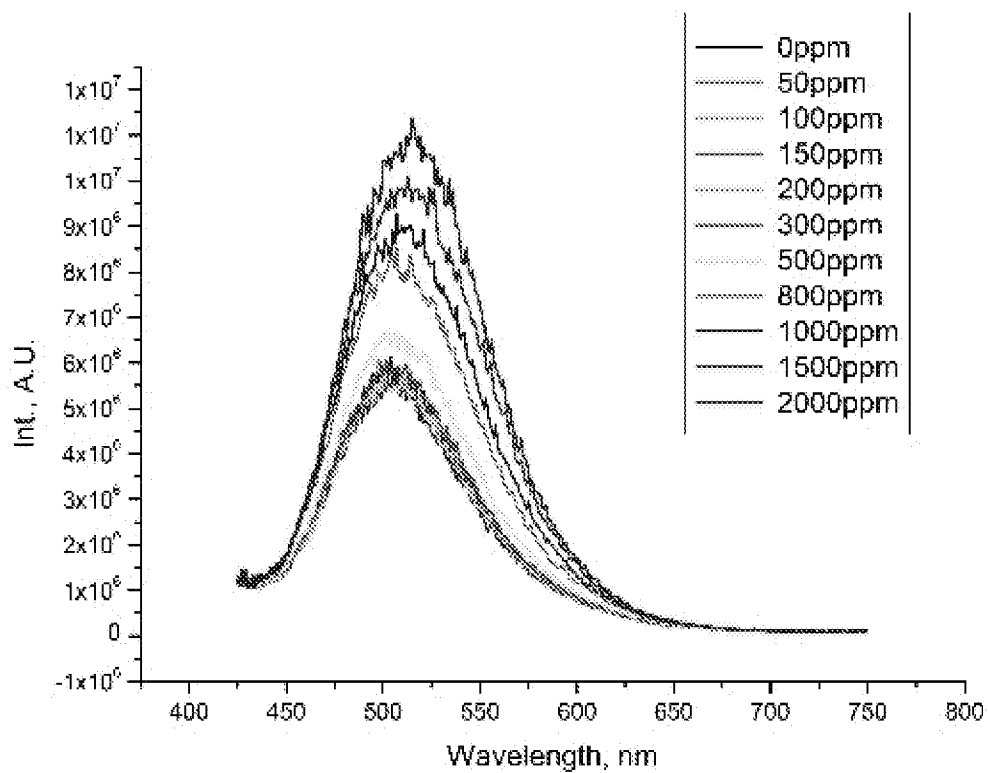


Fig. 4H

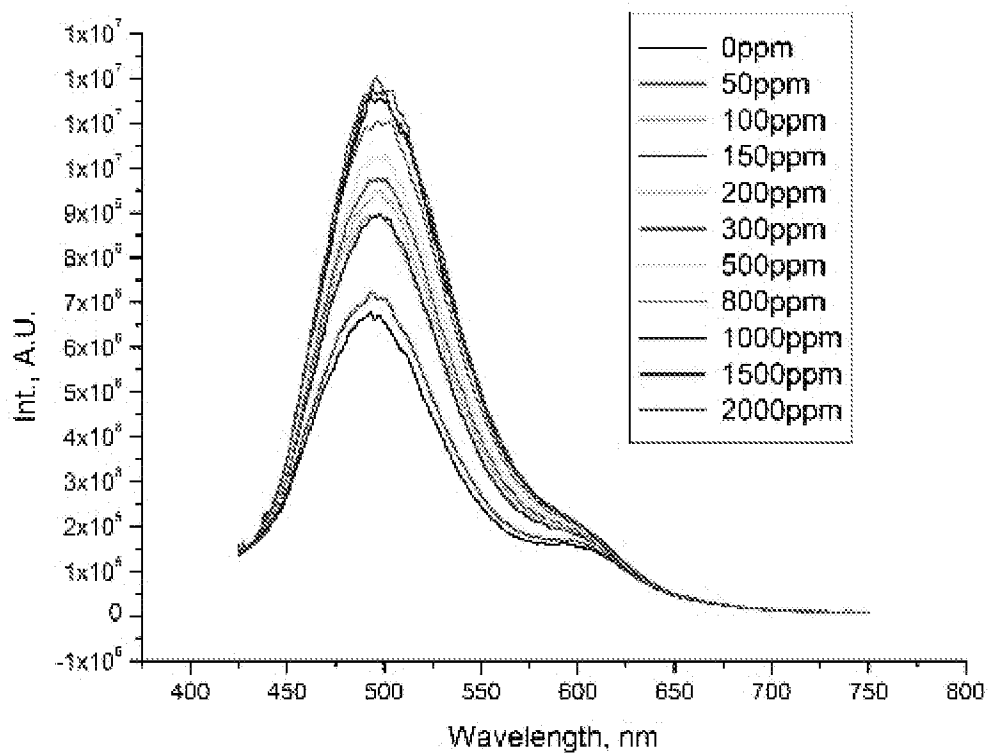


Fig. 4I

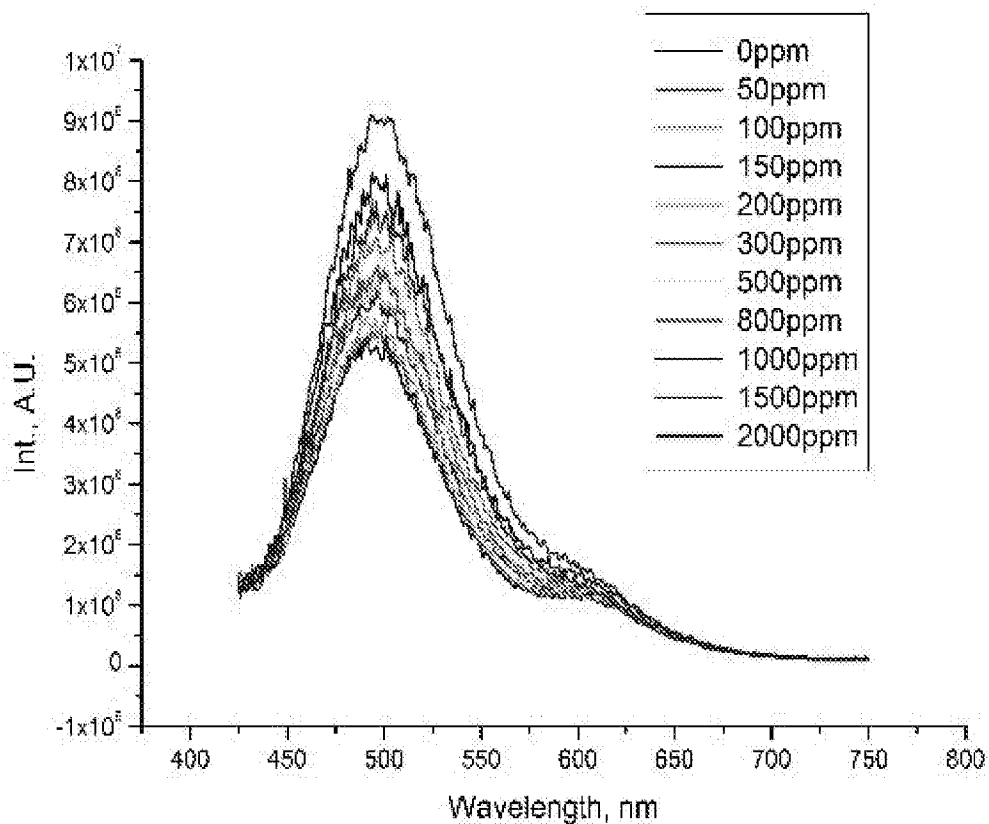


Fig. 4J

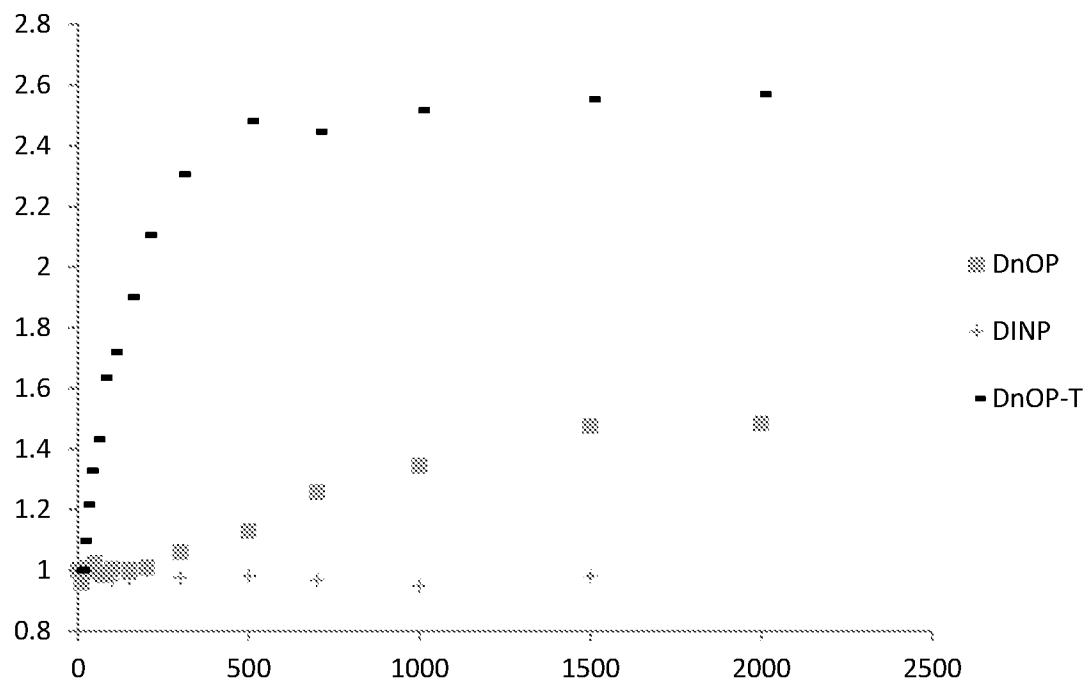


Fig. 5A

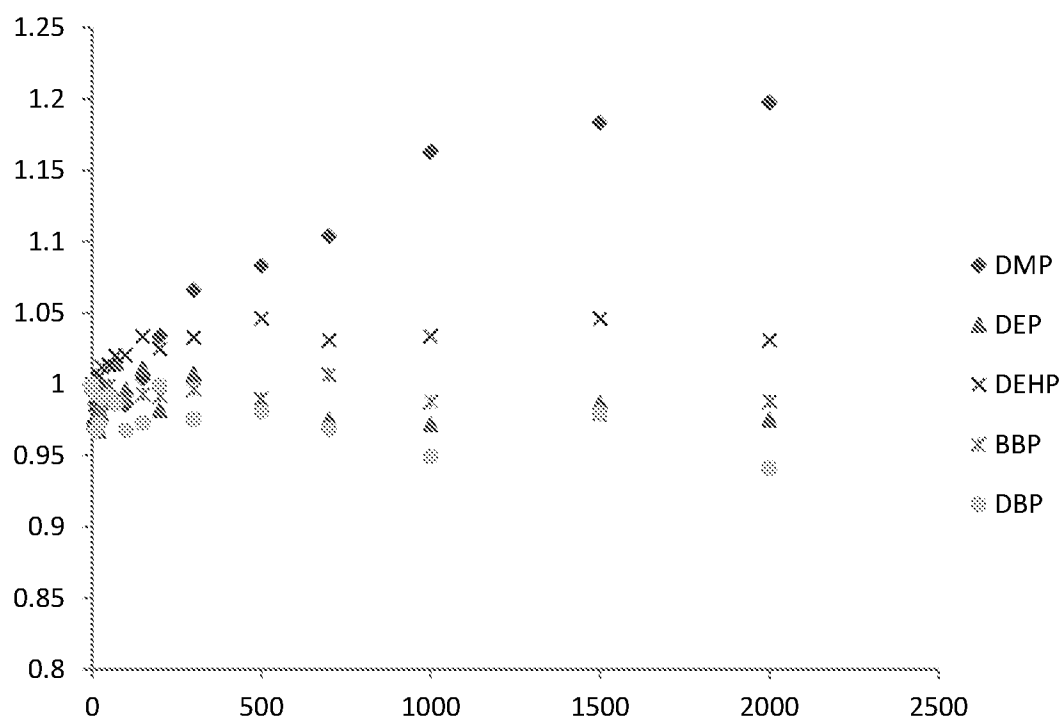


Fig. 5B

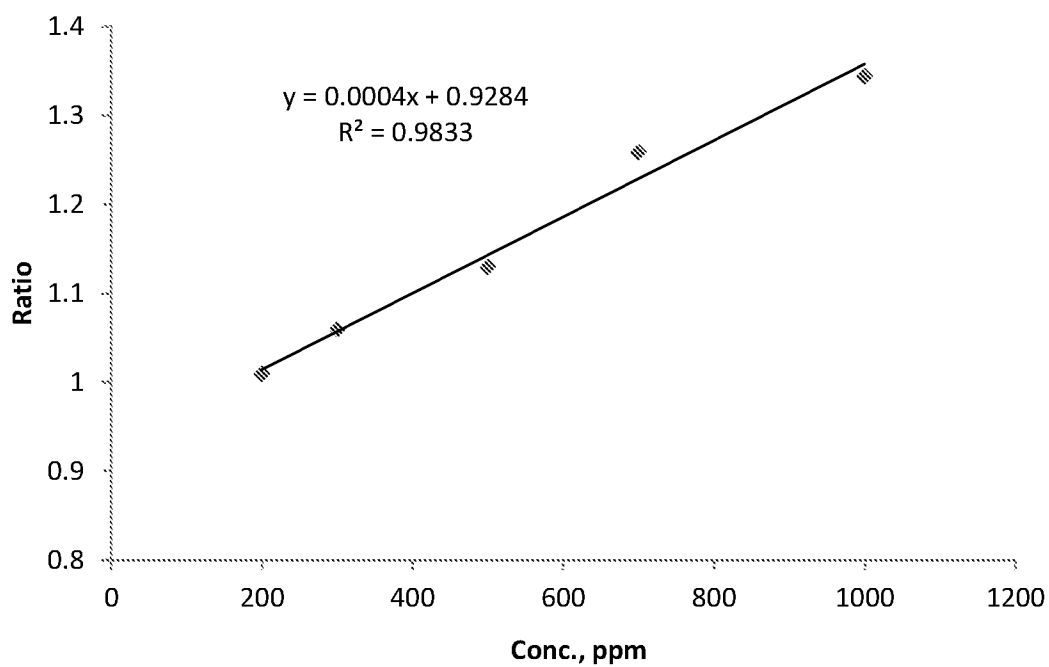


Fig. 6A

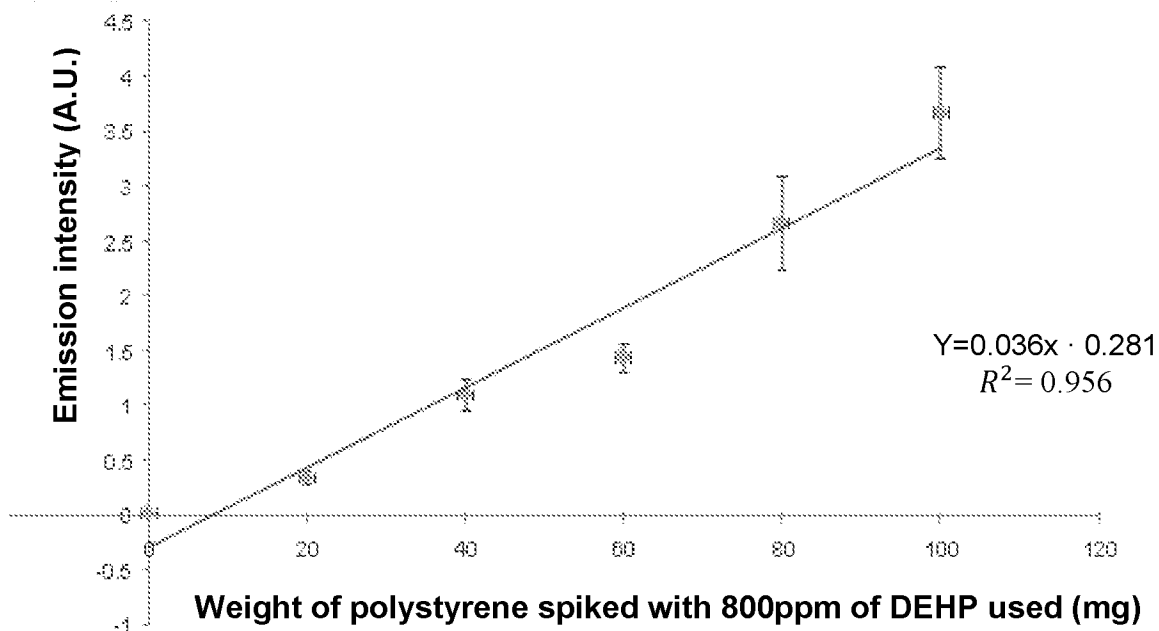


Fig. 6B

PDMS Microfluidic Capillary Device

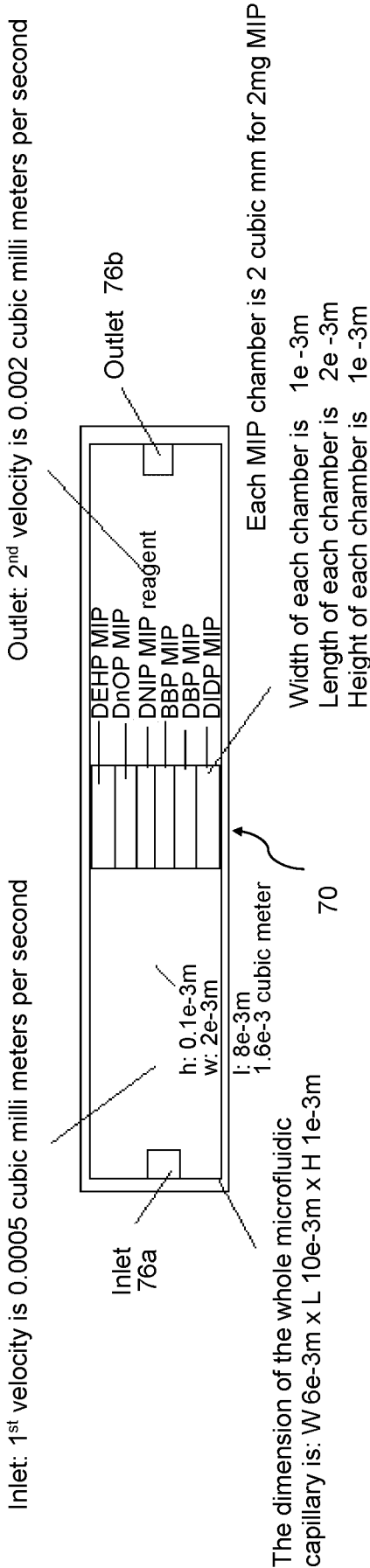


Fig. 7

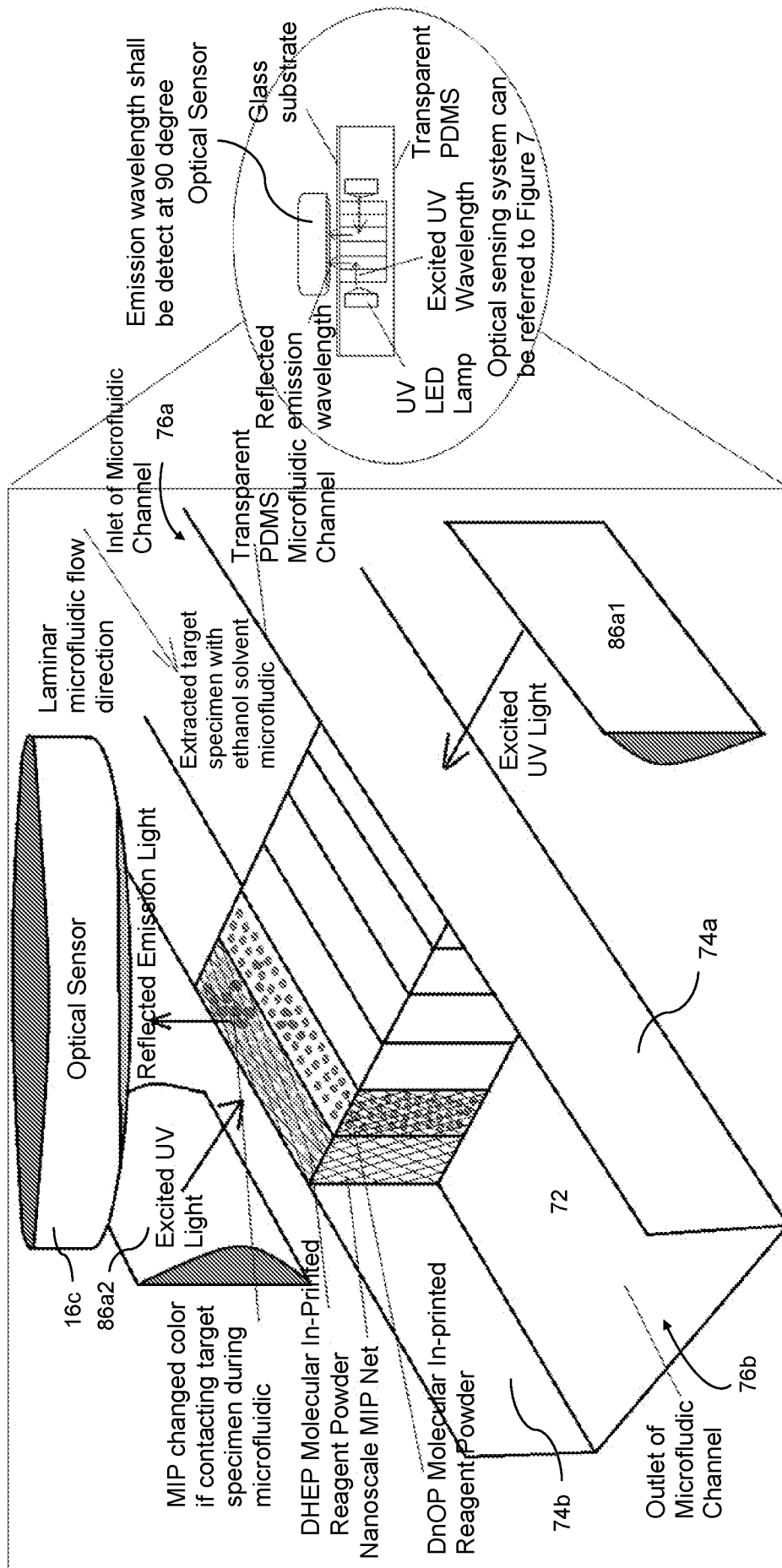


Fig. 8

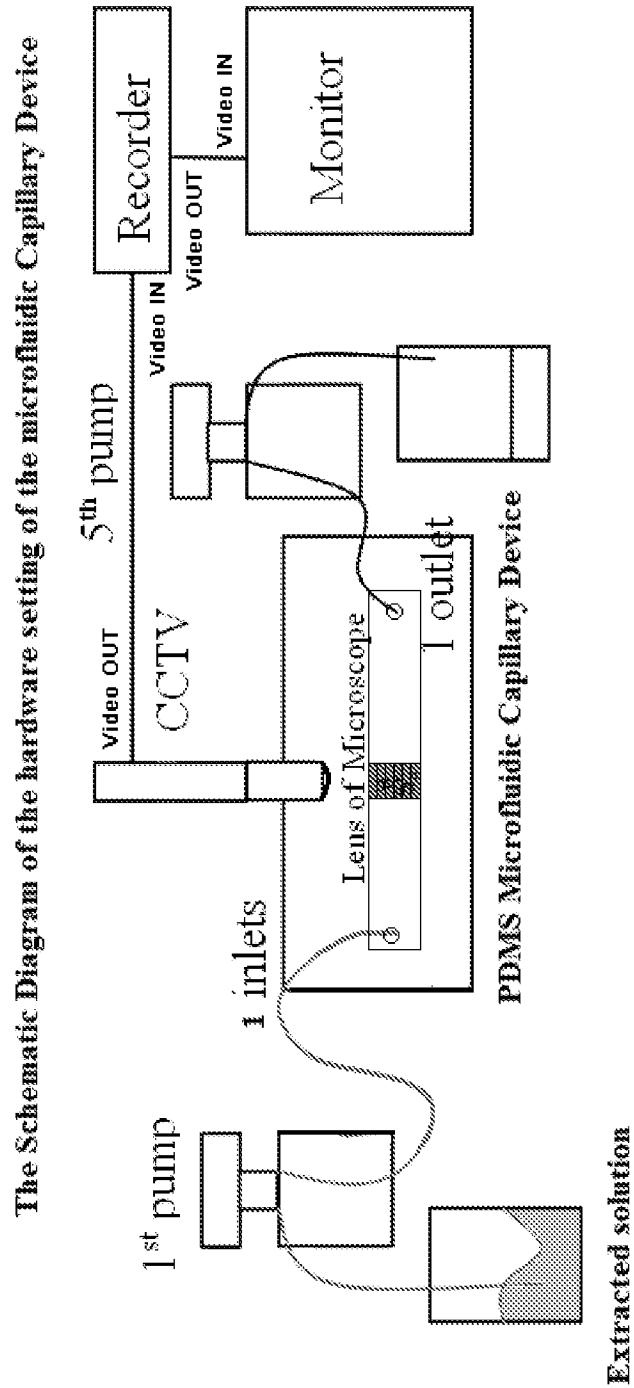


Fig. 9

PDMS Microfluidic Capillary Electrophoresis Device

Inlet: 1st velocity is 0.0005 cubic milli meters per second Outlet: 2nd velocity is 0.002 cubic milli meters per second

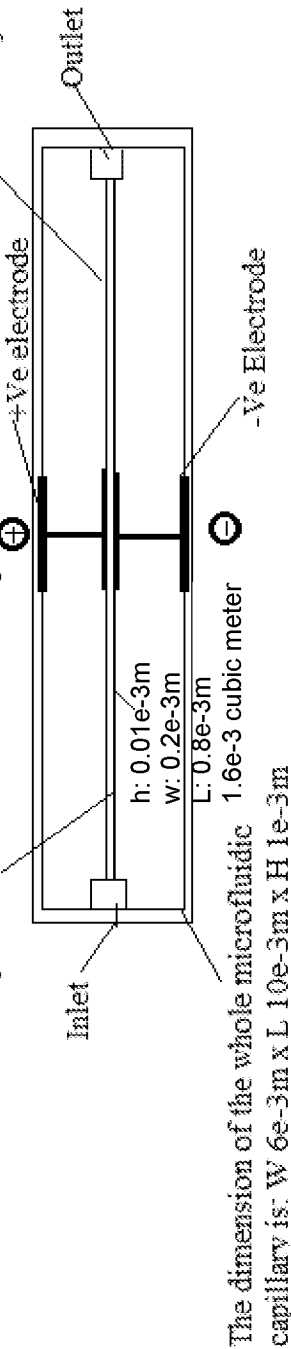


Fig. 10

Selectively those captured target phthalates / platicizer using MIP separated by superparamagnetic iron oxides (SPIO) nanoparticles material

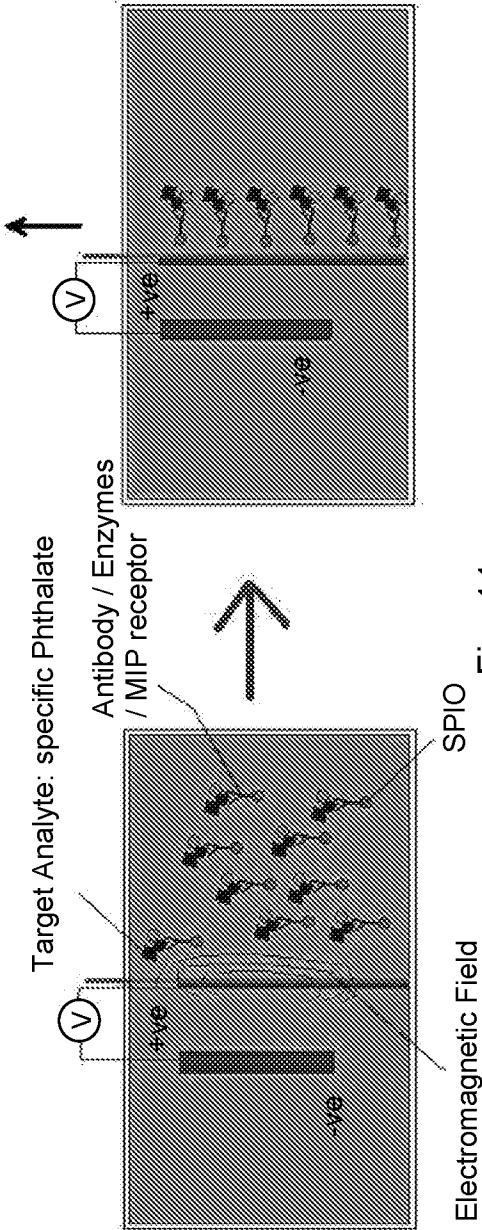


Fig. 11

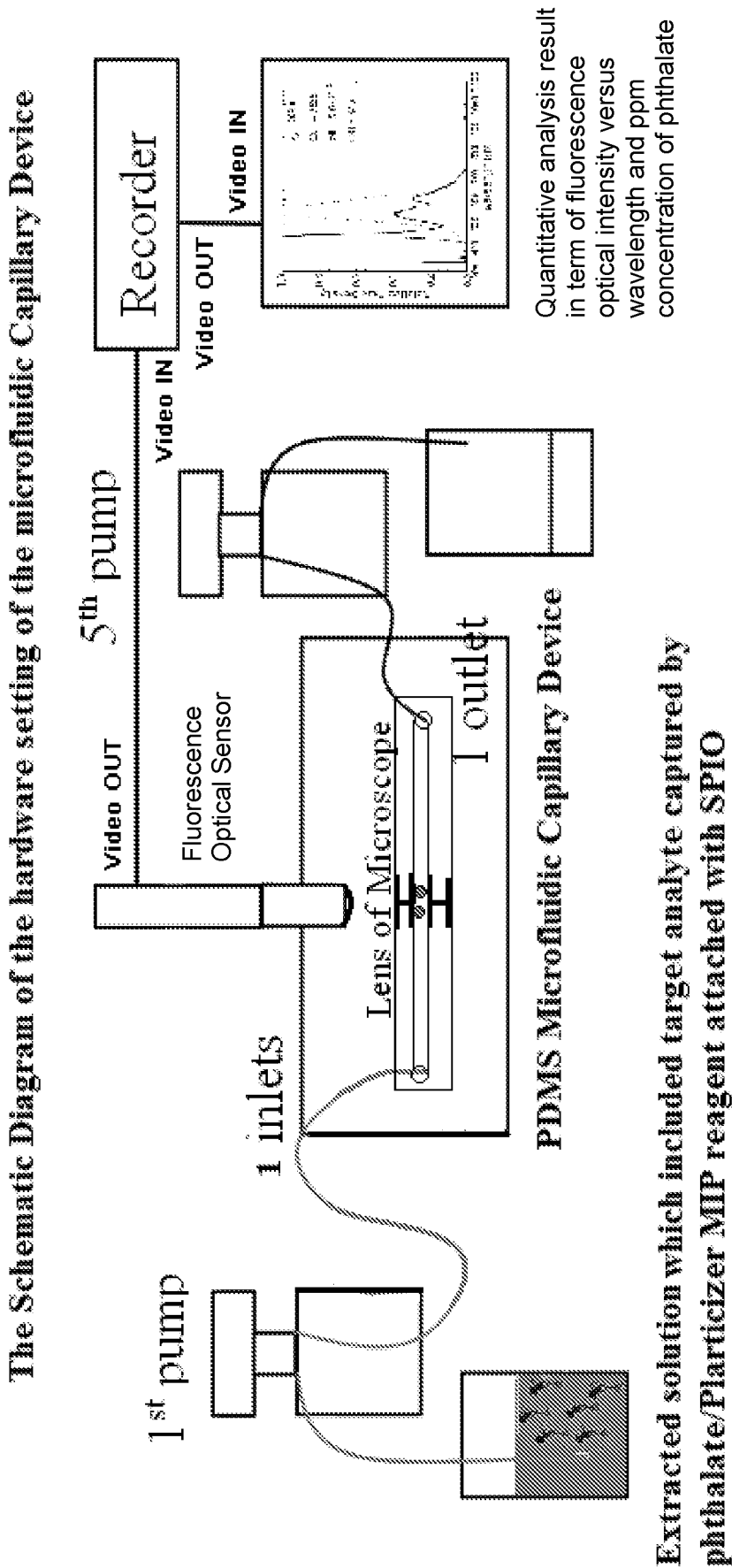


Fig. 12

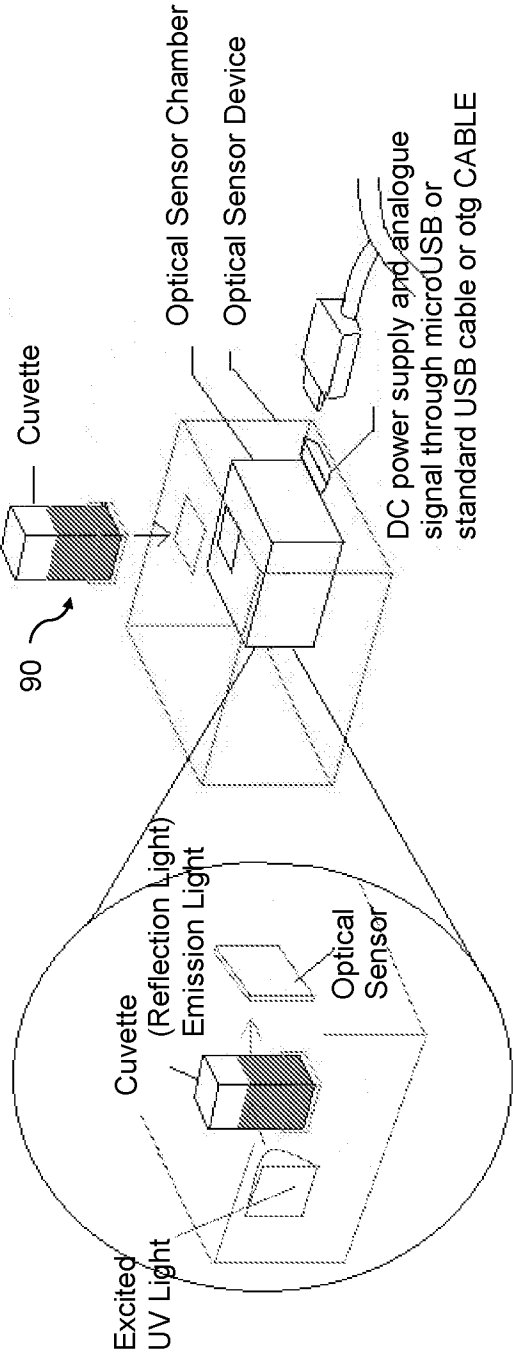


Fig. 13

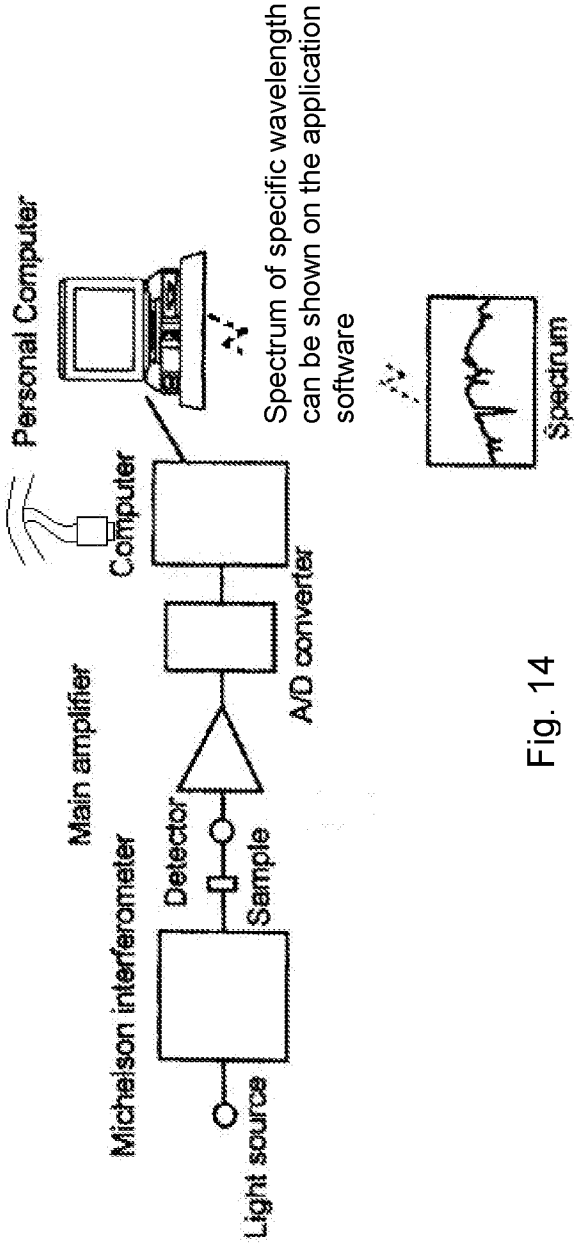


Fig. 14

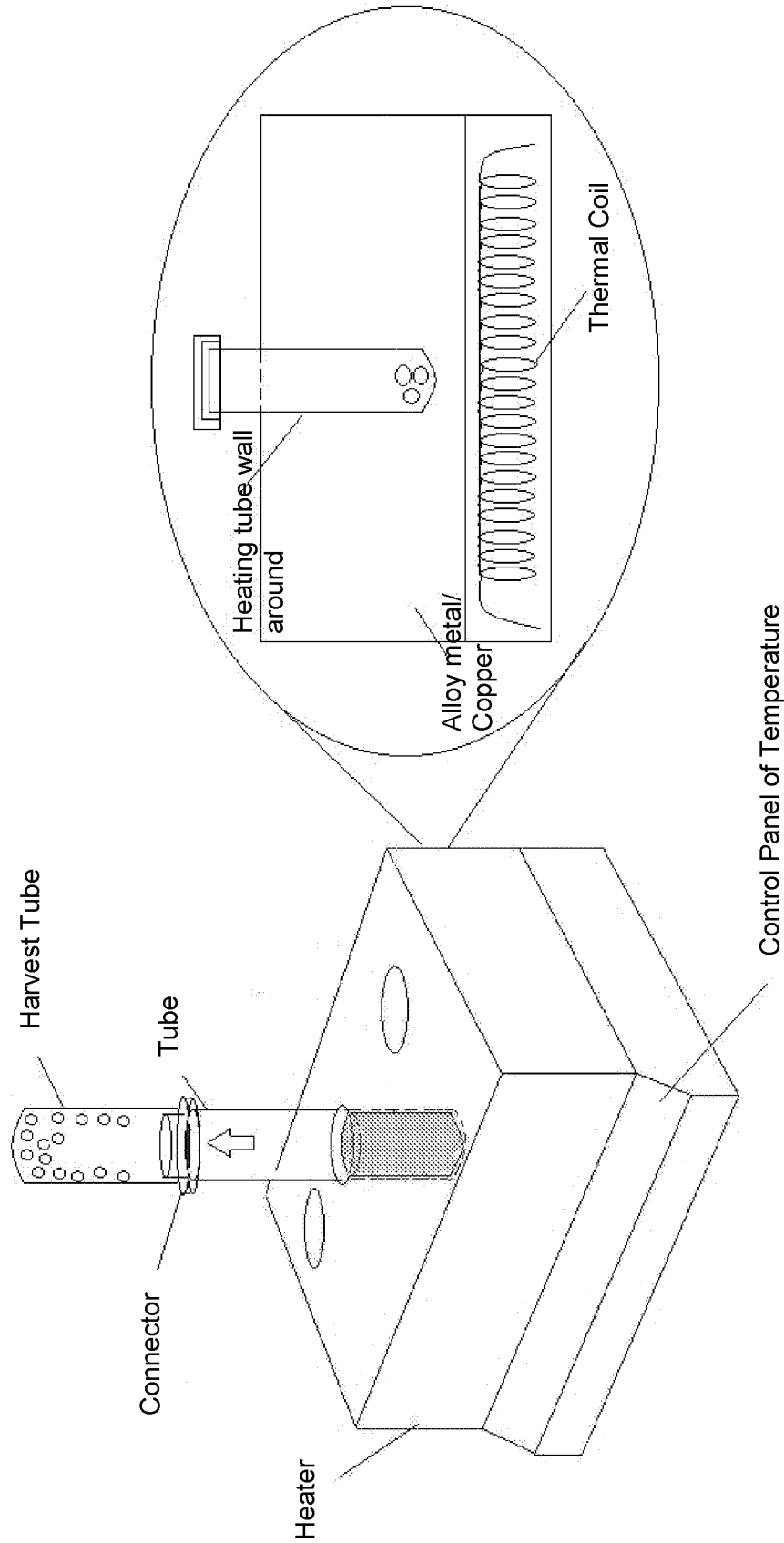


Fig. 15a

Fig. 15

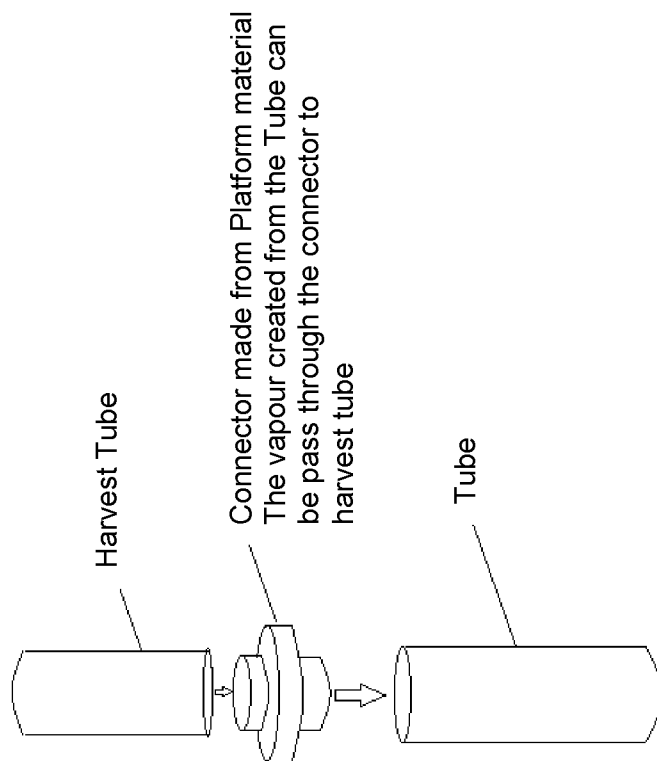


Fig. 16b

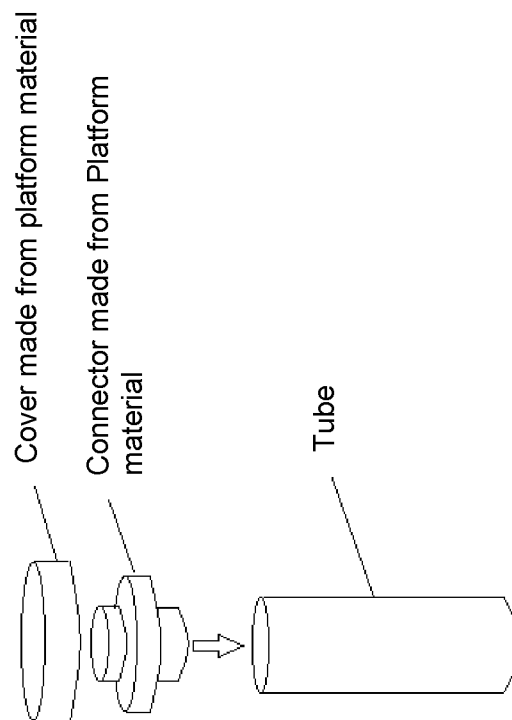


Fig. 16a

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB2017/050431

A. CLASSIFICATION OF SUBJECT MATTER

G01N 21/76(2006.01)i; G01N 21/78(2006.01)i; G01N 21/75(2006.01)i; C07D 213/04(2006.01)i; C08F 126/06(2006.01)i; C08F 226/06(2006.01)i

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)

G01N21, C07D213, C08F126, C08F226

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)

CNKI, CPRSABS, SIPOABS, CNABS, WPI, EPODOC, Web of Knowledge: molecularly imprinted, polymer, solvatochromic, phthalate

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2011017916 A1 (UNIV HONG KONG CITY) 17 February 2011 (2011-02-17) claims 1-23, paragraphs 62-92, Fig. 1-13	1-6, 10-13, 16
Y	WO 2011017916 A1 (UNIV HONG KONG CITY) 17 February 2011 (2011-02-17) claims 1-23, paragraphs 62-92, Fig. 1-13	9, 14-15
X	CN 103663377 A (WENGFU GROUP CO LTD) 26 March 2014 (2014-03-26) claims 1-5	7-8
Y	CN 103663377 A (WENGFU GROUP CO LTD) 26 March 2014 (2014-03-26) claims 1-5	9
Y	CN 102371084 A (CHINA PETROCHEMICAL CO LTD, ET AL.) 14 March 2012 (2012-03-14) claims 1-6 and paragraph 4	9, 14-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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

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

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

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

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

“&” document member of the same patent family

Date of the actual completion of the international search

09 June 2017

Date of mailing of the international search report

16 June 2017

Name and mailing address of the ISA/CN

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Telephone No. (86-10)62084571

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/IB2017/050431

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
WO	2011017916	A1	17 February 2011	US	2011003397	A1	06 January 2011
				CN	101962357	B	02 April 2014
				CN	101962357	A	02 February 2011
				US	8338553	B2	25 December 2012
CN	103663377	A	26 March 2014	None			
CN	102371084	A	14 March 2012	None			