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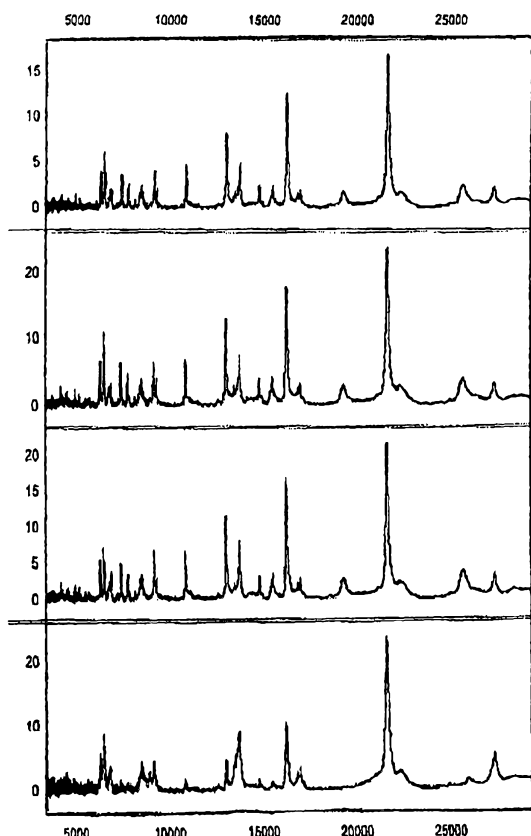
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(54) Title: USE OF MAGNETIC MATERIAL TO DIRECT ISOLATION OF COMPOUNDS AND FRACTIONATION OF MULTIPART SAMPLES



(57) Abstract: Methods for isolating a compound from a multi-part, typically biological sample. The methods use at least one paramagnetic particle having an associated electronic charge to bind compounds with the opposite charge to form a particle/compound complex. Alternatively, the paramagnetic particles have a ligand or functional group with an affinity for a target compound to form a particle/compound complex. The complex can be immobilized by applying a magnetic field to the particle/protein complex. The sample may be further processed to obtain a protein sample in a more pure form or a sample depleted of select compounds.

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**USE OF MAGNETIC MATERIAL TO DIRECT ISOLATION OF COMPOUNDS
AND FRACTIONATION OF MULTIPART SAMPLES**

The present application claims priority to U.S. Patent Application Serial No.
5 60/598,118 filed August 3, 2004.

Technical Field

The present invention relates generally to compositions and methods useful for
selectively purifying compounds from a multipart sample. More particularly, the present
10 invention relates to paramagnetic compounds and their use in methods for extracting
compounds in a directed manner either by affinity or ion-exchange chromatography methods.

Background Art

15 In the following discussion certain articles and methods will be described for
background and introductory purposes. Nothing contained herein is to be construed as an
“admission” of prior art. Applicant expressly reserves the right to demonstrate, where
appropriate, that the articles and methods referenced herein do not constitute prior art under
the applicable statutory provisions.

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Historically, purification schemes have been predicated on differences in the
molecular properties of size, charge and solubility between the compound to be purified and
the undesired contaminants contained therein. Protocols based on these parameters include
size exclusion chromatography, ion exchange chromatography, differential precipitation and
25 the like.

Size exclusion chromatography, otherwise known as gel filtration or gel permeation
chromatography, relies on the penetration of molecules in a mobile phase into the pores of
stationary phase particles. Differential penetration is a function of the hydrodynamic volume
of the particles. Accordingly, under ideal conditions, the larger molecules are excluded from
30 the interior of the particles, while the smaller molecules are accessible to this volume, and the
order of elution can be predicted by the size of the compound because a linear relationship
exists between elution volume and the log of the molecular weight.

Ion exchange chromatography involves the interaction of charged functional groups in the sample with ionic functional groups of opposite charge on an adsorbent surface. Two general types of interaction are known. The first is anionic exchange chromatography, which is mediated by negatively charged functional groups interacting with positively charged surfaces. The second is cationic exchange chromatography, which is mediated by positively charged functional groups interacting with negatively charged surfaces.

More recently, affinity chromatography and hydrophobic interaction chromatography techniques have been developed to supplement the more traditional size exclusion and ion exchange chromatographic protocols. Affinity chromatography relies on the interaction of the compound with an immobilized ligand. The ligand can be specific for the particular compound of interest, in which case the ligand is a substrate, substrate analog, inhibitor or antibody. Alternatively, the ligand may be able to react with a number of compounds. Such general ligands as adenosine monophosphate, adenosine diphosphate, nicotine adenine dinucleotide or certain dyes may be employed to recover a particular class of proteins.

Metal affinity partitioning exploits the affinity of transition metal ions for electron-rich amino acid residues, such as histidine and cysteine, accessible on the surfaces of some proteins. When the metal ion is partially chelated and coupled to a linear polymer, such as polyethylene glycol ("PEG"), the resulting polymer-bound metal chelate can be used to enhance the partitioning of metal binding proteins into the polymer-rich phase of a PEG-salt or PEG-dextran aqueous two-phase system.

The application of a metal affinity ligand for the isolation of proteins is known. It has been demonstrated that histidine- and cysteine-containing proteins could be chromatographically separated from each other using a support that had been functionalized with a chelator, such as iminodiacetic acid ("IDA"), which is attached to a polymer spacer and bound to a metal such as copper, zinc or nickel. Immobilized metal affinity chromatography ("IMAC") has evolved into a useful tool for protein chromatography and a number of IDA-based IMAC resins are now commercially available.

Many problems occur when using metal chelates to purify a target protein from a crude preparation. One problem in particular centers on the selectivity of the ligand for the target protein, i.e., the ligand can be under or over selective in binding the target protein. There also is a problem of nitrogen-containing compounds in a crude system inhibiting ligand binding to the target protein. Finally, there is a problem relating to protein

solubility and potential precipitation of proteins by the salt used in an aqueous, two-phase partitioning system. All of these problems can dramatically affect the target protein yield.

5 U.S. Patent No. 5,907,035 (Guinn) attempts to address the problems associated with metal chelation by using an aqueous, two-phase metal affinity partitioning system for purifying target proteins from crude protein solutions. The method includes the use of salts and inert hydrophobic molecules, such as polymers, to produce the aqueous two-phase system and the use of a polymer-chelator-metal complex to purify target
10 proteins by selectively binding them to the complex.

An effective and automated method of rapidly isolating small molecule compounds, macromolecules, or protein from crude samples has not been available. Precipitation techniques are still crude and difficult to automate. Chromatography is
15 expensive and time consuming. Thus, there remains a need for a technique to rapidly fractionate and isolate compounds in crude chemically diverse samples.

Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is not to be taken as an admission that
20 any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed before the priority date of each claim of this application.

Disclosure of Invention

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Throughout this specification the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of
30 any other element, integer or step, or group of elements, integers or steps.

30

In one aspect, there is provided a method for isolating a target compound from a sample comprising:

a) adding at least one paramagnetic particle comprising: a metal selected from the group consisting of iron, cobalt and nickel; a metallic compound chosen from the
35 group consisting of iron oxide, iron sulfide, iron chloride, ferric hydroxide, and ferrosferric oxide; and an organometallic compound, to a sample comprising one or

more target compounds selected from the group consisting of an antibody, a hapten, an enzyme, a polypeptide, and a protein, wherein the at least one paramagnetic particle has additionally attached to said paramagnetic particle one or more ligands or functional groups, wherein said ligand or functional groups have an affinity for one or more of the target compounds in the sample;

b) contacting the one or more ligands or functional groups with the one or more target compounds to form a complex;

c) immobilizing the complex by applying a magnetic field;

d) removing the portion of the sample not immobilized by the magnetic field;

e) removing the magnetic field to release the complex;

f) eluting the target compounds from said complex;

g) immobilizing the paramagnetic particles; and

h) retrieving the target compounds.

In a second aspect, there is provided a method for isolating a target compound from a sample comprising one or more target compounds and compounds not of interest, the method comprising:

a) adding at least one paramagnetic particle to a sample comprising one or more target compounds, wherein said paramagnetic particle has additionally attached to said paramagnetic particle one or more ligands or functional groups wherein said one or more ligands or functional groups having an affinity for one or more of target compounds not of interest in said sample, said target compound not of interest is selected from the group consisting of an antibody, a hapten, an enzyme, a polypeptide, and a protein;

b) contacting the ligands or functional groups with the compounds not of interest to form a complex;

c) immobilizing the complex by applying a magnetic field; and

d) removing the portion of the sample not immobilized by the magnetic field, wherein the sample thus removed contains the one or more target compounds.

In a third aspect, there is provided a method for isolating compounds from a sample, the method comprising:

a) adding at least one paramagnetic particle to a sample comprising one or more target compounds selected from the group consisting of an antibody, a hapten, an enzyme, a polypeptide, and a protein, wherein the at least one paramagnetic particle and the one or more target compounds have a charge difference;

- b) generating a complex between the one or more target compounds and the at least one paramagnetic particle;
- c) immobilizing the complex by applying a magnetic field;
- d) separating the complex immobilized by the magnetic field from the sample;
- 5 e) removing the magnetic field to release the complex;
- f) eluting said target compounds from the complex;
- g) immobilizing said paramagnetic particles; and
- h) retrieving the target compounds.

10 This invention provides methods for isolating one or more compounds from a multipart sample. The methods may be initiated by adding at least one paramagnetic particle to a sample comprising one or more target compounds. The at least one paramagnetic particle has attached thereto one or more functional groups or ligands, with each functional group or ligand having an affinity for one or more of the target

15 compounds in the sample. The methods continue by contacting the functional groups or ligands with the target compounds to form a complex. The complex is immobilized by an external magnetic field. The remaining portion of the sample not immobilized is removed leaving the target compounds for further processing. The complex can be further manipulated by removing the magnetic field thereby freeing the complex so that

20 additional chemistry or purification methods can be performed on the complex. Alternatively, compounds other than the compound of interest could be bound in complex and separated from the remaining solution. The solution that is not immobilized could be separated from the bound material and manipulated as needed in this more concentrated state.

25 A method of the invention for isolating a target compound from a sample can comprise: a) adding at least one paramagnetic particle chosen from the group consisting of iron oxide, iron sulfide, iron chloride, ferric hydroxide, and ferrous ferric oxide to a sample comprising one or more target compounds, wherein said at least one

30 paramagnetic particle has one or more ligands or functional groups attached thereto, said ligands or functional groups having an affinity for one or more of the target compounds in said sample; b) contacting the one or more ligands or functional groups with the one or more target compounds to form a complex; c) immobilizing the complex by applying a magnetic field; d) removing the portion of the sample not

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immobilized by the magnetic field; e) removing the magnetic field to release the complex; f) eluting said target compounds from said complex; g) immobilizing said paramagnetic particles; and h) retrieving said target compounds.

- 5 A method of the present invention may be performed as set forth above, and wherein said one or more ligands or functional groups are covalently bound to the at least one paramagnetic particle

A method of the present invention may be performed as set forth above, and wherein said one or more ligands or functional groups are specific for a target compound selected from the group consisting of an antibody, an antigen, a hapten, a receptor, an enzyme, a polypeptide, a protein and a polynucleotide.

5 A method of the present invention may be performed as set forth above, and wherein the at least one paramagnetic particle is a metal selected from the group consisting of iron, cobalt, and nickel.

A method of the present invention may be performed as set forth above, and wherein said one or more ligands or functional groups are attached through biological linkages.

10 A method of the present invention may be performed as set forth above, and wherein said biological linkages are selected from the group consisting of streptavidin-biotin, avidin-biotin, carbohydrates-lectins, and enzyme-enzyme inhibitors.

An alternative method for isolating a target compound from a sample comprising one or more target compounds and compounds not of interest, the method comprising: a) adding
15 at least one paramagnetic particle to a sample comprising one or more target compounds, wherein said at least one paramagnetic particle has one or more ligands or functional groups attached thereto, said one or more ligands or functional groups having an affinity for one or more of target compounds not of interest in said sample; b) contacting the ligands or functional groups with the compounds not of interest to form a complex; c) immobilizing the
20 complex by applying a magnetic field; and d) removing the portion of the sample not immobilized by the magnetic field, wherein said sample thus removed contains the one or more target compounds.

A method of the present invention may be performed as described above, and wherein said one or more ligands or functional groups are covalently bound to the paramagnetic
25 particle.

A method of the present invention may be performed as described above, and wherein said one or more ligands or functional groups are specific for a compound selected from the group consisting of an antibody, an antigen, a hapten, a receptor, an enzyme, a polypeptide, a protein, and a polynucleotide.

A method of the present invention may be performed as described above, and wherein the at least one paramagnetic particle is a metal selected from the group consisting of iron, cobalt, and nickel.

5 A method of the present invention may be performed as described above, and wherein the at least one paramagnetic particle is an iron compound selected from the group consisting of iron oxide, iron sulfide, iron chloride, ferric hydroxide and ferrosferric oxide.

A method of the present invention may be performed as described above, and wherein said one or more ligands or functional groups are attached through biological linkages.

10 A method of the present invention may be performed as described above, and wherein said biological linkages are selected from the group consisting of streptavidin-biotin, avidin-biotin, carbohydrates-lectins, and enzyme-enzyme inhibitors.

A further alternative method for isolating compounds from a sample may comprise: a) adding at least one paramagnetic particle to a sample comprising one or more target compounds, wherein said at least one paramagnetic particle and said one or more target
15 compounds have a charge difference; b) generating a complex between said one or more target compounds and said at least one paramagnetic particle; c) immobilizing the complex by applying a magnetic field; d) separating the complex immobilized by the magnetic field from the sample; e) removing the magnetic field to release the complex; f) eluting said target compounds from said complex; g) immobilizing said paramagnetic particles; and h)
20 retrieving said target compounds.

A method of the invention may be performed as described above, and wherein the at least one paramagnetic particle has one or more charged functional groups attached thereto to provide the at least one paramagnetic particle with an overall charge.

25 A method of the present invention may be performed as described above, and further comprising the steps of centrifuging, filtration, purifying via affinity chromatography and resolving the complex prior to applying the magnetic field.

A method of the present invention may be performed as described above, and wherein the sample is altered by changing the sample pH.

A method of the present invention may be performed as described above, and wherein the sample is altered by changing the ionic strength.

A method of the present invention may be performed as described above, and wherein the at least one paramagnetic particle is a metal selected from the group consisting of iron, cobalt, and nickel.

The present invention also relates to kits for isolating proteins from samples, with the kits comprising a combination of some, or all, of the constituents described above.

Other objects, purposes and advantages of the present invention will become apparent with the following description of the invention.

10

Brief Description of the Drawings

The foregoing and other features, aspects and advantages of the present invention will become apparent from the following description, appended claims and the exemplary embodiments shown in the drawing, which is briefly described below. It should be noted that, unless otherwise specified, like elements have the same reference numbers.

Fig. 1 is a side by side comparison of mass spectrometry chromatographs on human plasma samples illustrating the enhanced resolution gained by pre-treating the plasma samples with magnetic particles having one or more protein affinity ligands or functional groups attached.

20

Modes for Carrying Out The Invention

The principles of the present invention will now be further described by the following discussion of certain illustrative embodiments thereof and by reference to the foregoing drawing figure.

25

The present invention relates to unique compositions of matter and their methods of use to extract target compounds from crude organic or biological samples.

30

This invention provides methods for isolating one or more compounds from a multipart sample. The methods may be initiated by adding at least one paramagnetic particle to a sample comprising one or more target compounds. The at least one paramagnetic particle has attached thereto one or more ligands or functional groups, with each ligand or functional group having an affinity for one or more of the target compounds in the sample. The methods continue by contacting the ligands or functional groups with the target compounds to form a complex. The complex is immobilized by an external magnetic field. The sample not immobilized is removed leaving the target compounds for further processing. The complex can be further manipulated by removing the magnetic field thereby freeing the complex so that additional chemistry or purification methods can be performed on the complex.

In one embodiment, the present invention uses at least one electronically charged paramagnetic particle to differentially bind and separate target compounds having a charge opposite that of the at least one paramagnetic particle. Electronic charge differences can be generated between the at least one paramagnetic particle and one or more of the target compounds by altering the sample.

As used herein, the term "paramagnetic particle(s)" means particle(s) capable of having a magnetic moment imparted to them when placed in a magnetic field. Typically, the paramagnetic particles consist of either metallic iron, cobalt or nickel. These elements are the only known to exist in a paramagnetic state while in their ground or zero oxidation state. In addition to these three metals, organic and organometallic compounds also possess paramagnetic properties and may also be used.

As used herein, the term "sample" refers to the sample solvent and the inorganic and organic solutes contained within the sample solvent. The sample is typically in the solution phase, but may also exist in other phases of matter including gel, gas-phase, paste or the like. The sample can be altered by changing solvent conditions or by directly changing one or more of the organic agents within the sample. The sample can be altered to create sufficient charge differences between the paramagnetic particle and the target compounds by changing any one of the sample elements or a combination thereof.

For example, but not by way of limitation, changes to the pH or the ionic strength of the sample can associate different charges on the paramagnetic particle and the target compounds. Ionic strength and pH can be optimized to create binding conditions that will

differentially bind a target compound mixed with a group of compounds sharing other, less distinguishable physical properties with the target compound. Alternatively, chemistry can be performed on the compounds contained within the sample solvent to promote charge differences between the paramagnetic particle and the target compound. Specific chemistry that can be performed on the target compounds includes, but is not limited to, the esterification of carboxylic groups, the addition of protective groups, or by protein/peptide modification techniques including citraconylation, maleylation, trifluoroacetylation, succinylation, tetrafluorosuccinylation or the like.

If non-specific fractionation through ion exchange is adequate for a particular application, then non-liganded, paramagnetic particles or paramagnetic particles containing only carboxylic or amine functional groups can be utilized.

The present invention may be used to reduce protein from a sample prior to releasing nucleic acid from a host cell or an infecting organism. This may be helpful in improving nucleic acid binding kinetics. The technique is helpful in instances in which a nucleic acid preparation free of protein is required. In addition, the invention can be used to extract a subset of the total protein sample population by manipulating the protein binding conditions. Using the invention for these purposes gives rise to two distinct uses: (1) selectively binding the protein of interest, discarding the unbound sample or proteins not of interest, and eluting the bound proteins for further analysis; and (2) where the bound protein does not contain the protein of interest, the bound protein or protein not of interest is discarded and the unbound sample containing the protein of interest is collected for further analysis. Under both scenarios, the compound of interest can be resolved using additional chromatography techniques to further isolate the particular compound of interest from other compounds that share similar charge characteristics.

According to the present invention, when a paramagnetic particle carries an electronic charge, the paramagnetic particle will reversibly bind to target molecules having an overall charge opposite that of the paramagnetic particle. The paramagnetic particle and the target molecule, therefore, bond to form a target molecule/particle complex.

Charge may be associated with the paramagnetic particle in any number of ways. In one embodiment, charge can be associated by attaching charged ligands or functional groups to the paramagnetic particle. In another embodiment, charge can be associated to the paramagnetic particle by simply increasing or decreasing the pH of the sample solution

surrounding the particle. In either embodiment, the overall charge on the paramagnetic particle can be positive or negative depending on the ligand or functional group (anionic or cationic), pH or ionic strength of the sample.

5 Although not desiring to be bound by a particular theory, it is believed that when acid is used to associate charge, the acidic environment increases the electropositive nature of the metallic portion of the paramagnetic particle. It is also believed that the low pH conditions increase the binding of the particles to the electronegative portions of a target compound, e.g., in proteins or polypeptides, or regions high in glutamic acid and aspartic acid.

10 Paramagnetic particles, when placed in a magnetic field, are movable under the action of the field. Such movement is useful for moving bound target compounds in a sample processing protocol or for other manipulations. Thus, target compounds bound to the paramagnetic particles can be immobilized to the interior of a receptacle holding the sample or moved to different areas for exposure to different reagents and/or conditions with minimal direct contact because of the application of magnetic force.

15 The paramagnetic particles useful in the present invention need not be complicated structures. Suitable paramagnetic particles include iron particles, and the iron may be an iron oxide of forms such as ferric hydroxide and ferrosferric oxide, which have low solubility in an aqueous environment. Other iron particles such as iron sulfide and iron chloride may also
20 be suitable for binding and extracting target compounds using the conditions described herein.

Similarly, the shape of the paramagnetic particles is not critical to the present invention. The paramagnetic particles may be of various shapes including, for example, spheres, cubes, oval, capsule-shaped, tablet-shaped, nondescript random shapes, etc. and may
25 be of uniform shape or non-uniform shapes. Whatever the shape of the paramagnetic particles, the diameter at the widest point is generally in the range of from about 0.05 μm to about 50 μm , particularly from about 0.1 to about 0.3 μm .

In instances when acid or ionic strength is used to associate charge to the paramagnetic particles or the target compounds, the pH or ionic strength can be provided
30 through a variety of means. For example, the paramagnetic particles can be added to an acidic solution or an acidic solution may be added to the particles. Alternatively, a solution or environment in which the paramagnetic particles are located can be acidified by addition

of an acidifying agent such as hydrochloric acid, sulfuric acid, phosphoric acid, acetic acid, citric acid or the like.

Provided that the environment in which the paramagnetic particles are located is of a pH less than about 7.0, the particles will reversibly bind target molecules having an overall negative charge. Furthermore, the protein binding capacity of the paramagnetic particles (without ligands or functional groups attached) increases as the pH decreases. Alternatively, as the solution approaches a neutral or higher pH, and the overall charge on the paramagnetic particles become negative, positively-charged proteins can be bound. As shown below in Example 1, optimal extraction for the paramagnetic particle, ferrosiferrous oxide, occurs at pH ranges between 3-4 and 9-10.

Without desiring to be held to a particular theory, it is believed that the present invention can replace other crude protein fractionation techniques because the acidic solution of the present invention promotes the binding of electropositive paramagnetic particles to electronegative protein molecules in preference to other substances in a sample such as water-soluble organic salts and other organic reagents.

As stated above, in an acidic environment, electropositive paramagnetic particles, such as ferric oxide particles, will bind electronegative protein molecules. Thus, the present invention can be used to fractionate sample proteins based on charge. Using the protocol of the present invention, one would expect only positively-charged proteins to be extracted. Reagents can be added to samples to impart overall negative charge on sample proteins. For example, lysine residues could be reversibly modified by citraconylation. Likewise, arginine residues could be modified by 1,2-cyclohexanedione. Other means of introducing a negative charge to proteins include maleylation, trifluoroacetylation, succinylation and tetrafluorosuccinylation. Various detergents, such as, e.g., sodium dodecylsulfate (SDS), could also be used.

A similar approach to protein modification can also be used to impart an overall positive charge on proteins, thereby preventing binding. This could be done to improve extraction efficiency and product purity by adding another means to fractionate the protein sample. Materials other than the protein to be bound could, therefore, be positively charged so that they are not attracted to the negatively-charged paramagnetic particles. The positively-charged material would remain in solution so that it could be extracted from the bound protein held by the paramagnetic particles. Such separation can be accomplished by

means known to those skilled in the art such as centrifugation, filtering, application of magnetic force and the like.

The bound protein molecules can then be eluted into an appropriate buffer for further manipulation or characterization by various analytical techniques. The elution may be accomplished by heating the environment of the particles with bound proteins and/or raising the pH of the environment. Agents that may be used to aid the elution of protein from paramagnetic particles include basic solutions such as potassium hydroxide, sodium hydroxide or any compound that will increase the pH of the environment to an extent sufficient to displace electronegative protein from the particles.

The present invention also provides methods capable of using paramagnetic particles to isolate compounds using affinity-based chromatography. According to these methods, at least one paramagnetic particle is added to a sample receptacle containing one or more organic or biological target compounds. The paramagnetic particle has covalently attached thereto one or more ligands or functional groups that have an affinity for one or more of the target compounds. The ligands or functional groups are allowed to interact and contact the target compounds, thereby forming a particle-compound complex. The complex is then immobilized by applying an external magnetic field. The unbound sample or the immobilized complex can then be removed from the sample receptacle. If the immobilized complex is removed from the sample, additional chemistry or chromatography can be applied to the sample. A specific example of this aspect of the invention would be the depletion of high abundance proteins from serum prior to evaluating the sample by an analytical instrument such as a mass spectrometer. Because of the large concentrations of serum albumin, immunoglobulins, and transferrin relative to other serum proteins, removal of these proteins prior to sample analysis by mass spectrometry greatly enhances resolution of other proteins or compounds. Specifically, Protein A and/or Protein G could be utilized as ligands or functional groups to bind immunoglobulins. Native Protein G also has a binding site for albumin. This binding site is usually engineered out so that the Protein G is more specific for immunoglobulins. However, native Protein G with its human albumin binding site, could be utilized as a ligand or functional group with a paramagnetic particle to demonstrate an affinity chromatography system capable of high throughput albumin depletion for mass spectrometry sample preparation.

Likewise, the present invention can be used to deplete select compounds not of interest from a sample by binding the compounds to one or more solid-phase paramagnetic particle, and subsequently removing the unwanted compound from the sample. For example, when combining serum and paramagnetic particles containing ligands or functional groups with a particular affinity for the protein albumin, preferential binding of albumin occurs leaving behind proteins of interest such as disease markers. Using this approach in conjunction with automated equipment (such as the Becton, Dickinson and Company ("BD") Viper platform) equipped with a magnetic extraction block allows easy automation of the fractionation/isolation protocol.

The affinity chromatography method may also remove the unbound sample from the sample receptacle leaving the immobilized complex behind. The magnetic field can be removed releasing the complex into the receptacle so that additional chemistry can be performed on the complex including, but not limited to, releasing the target compound from the paramagnetic particle. In either of the above scenarios, i.e., removing the complex or retaining the complex in the receptacle, the method can be used in conjunction with hardware incorporating external magnets (such as the BD Viper platform) to enable automated high-throughput sample fractionation and compound isolation.

Additional ligand/receptor systems can be used with paramagnetic particles to create other affinity chromatography systems. In addition to Protein A and Protein G, antibodies, antigens, haptens, receptors, enzymes and polypeptide and polynucleotide sequences can all be used as the ligand or functional group with good effect. In addition, paramagnetic particles have been combined with biological linkages including streptavidin-biotin, avidin-biotin, carbohydrate-lectins, and enzyme-enzyme inhibitor systems.

The present invention also relates to kits for isolating proteins from samples, with the kits comprising at least one paramagnetic particle. The kits may also include a source for imparting or altering the charge of the paramagnetic particle, such as an acid. The kit may also include a magnet or another means for creating a magnetic field to be used in the methods described herein. The kits of the current invention may or may not include standard labware that may be used in performing the methods of the current invention, such as tubes, syringes, and filter paper.

The following Examples illustrate specific embodiments of the invention described in this document. As would be apparent to skilled artisans, various changes and modifications are possible and are contemplated within the scope of the invention described.

Example

5 *Example 1 – Magnetic Particle Based Affinity Chromatography To Enhance Mass Spectroscopic Analysis*

This Experiment was performed to evaluate magnetic particle-based affinity chromatography as a means to reduce plasma albumin and IgG content, thereby enhancing mass spectroscopic analysis of other sample proteins of interest. The procedure is outlined in

10 Table I below:

Table I

STEP	EVENT
1.	Wash strept-avidin magnetic particles 3X with 1X PBS, place magnet next to tube to immobilize particles, and remove supernatant by aspiration.
2.	Resuspend magnetic particles with 1X PBS to a concentration of 6 mg/mL.
3.	Add 25 μ L of 4mg/mL biotinylated Rabbit anti-human serum albumin to tube containing 200 μ L of 6 mg/mL washed strept-avidin magnetic particles (Tube 1).
4.	Add 25 μ L of 2.9 mg/mL biotinylated monoclonal anti-human IgG1 to tube containing 200 μ L of 6 mg/mL washed strept-avidin magnetic particles (Tube 2).
5.	Incubate both tubes 30 minutes with gentle mixing on a rotating stand.
6.	Mix and transfer 100 μ L from Tube 1 and 100 μ L from Tube 2 to a new tube (Tube 3). Tube 1: Magnetic Particle – Strept-avidin – Biotin – Rabbit Anti-human Albumin Tube 2: Magnetic Particle – Strept-avidin – Biotin – Monoclonal Anti-human IgG1 Tube 3: Equal mix of Tube 1 and Tube 2 particles (Anti- human Albumin and Anti-human IgG1)
7.	Wash tubes 1,2, and 3 three times with 1X PBS, place magnets next to tubes to immobilize particles, and remove supernatant by aspiration.
8.	Dilute 20 μ L human plasma sample 1:10 by adding to 180 μ L 1X PBS
9.	Transfer 20 μ L 1:10 diluted human plasma to each of 3 tubes (Tube 1, 2, and 3) and incubate for 10 minutes
10	Remove supernatant by aspiration after placing tubes next to magnets to immobilize particles.
11.	Analyze the 3 particle treated samples by mass spectrometry using Ciphergen WCX2 chips.
12.	Dilute untreated plasma 1:30 with 1X PBS and analyze by mass spectrometry (WCX2 chip). This sample serves as a control for Tubes 1, 2, and 3.
13.	Use 50% acetonitrile containing 0.1% TFA as mass spectrometry matrix.

The procedure used to conduct the experiment, outlined in Table I, begins by washing strept-avidin coated magnetic particles three times with 1X phosphate buffer solution (PBS). The PBS solution is removed by aspiration and the particles are immobilized by placing a magnet next to the collection vessel. In the second step the magnetic particles are resuspended with 1X PBS to a concentration of 6 mg/mL. In step three, 25 μ L of 4 mg/mL biotinylated Rabbit anti-human serum albumin is added to the collection vessel (Tube 1) containing 200 μ L of 6 mg/mL washed strept-avidin magnetic particles. In step four, a second collection vessel, (Tube 2) is produced by adding 25 μ L of 2.9 mg/mL biotinylated monoclonal anti-human IgG1 to a tube containing 200 μ L of 6 mg/mL washed strept-avidin magnetic particles. In step five, both collection vessels (Tube 1 and Tube 2) are incubated for 30 minutes with gentle mixing. Tubes 1 and 2 are mixed in step six to generate a third collection vessel, (Tube 3). Tube 3 is an equal mix of Tube 1 and Tube 2. In step seven the three collection vessels are washed with 1X PBS. The PBS is again removed by aspiration following immobilization of the particles by an external magnet. In step eight, 20 μ L of human plasma sample is diluted 1:10 by adding 180 μ L of 1X PBS. A 20 μ L aliquot of the dilute human plasma sample (step eight) is added to each of Tubes 1, 2, and 3. The tubes are incubated for 10 minutes to complete step nine. The supernatant in each of Tubes 1, 2, and 3 is removed in step ten following immobilization of the strept-avidin magnetic particles by an external magnet. In step eleven particles from each tube are analyzed by mass spectrometry using Ciphergen WCX2 chips. Dilute untreated plasma 1:30 with 1X PBS is also analyzed by mass spectrometry (WCX2 chip). This sample serves as a control for the particles analyzed from Tubes 1, 2, and 3. The mass spectrometry matrix used in the control and for all samples is 50% acetonitrile containing 0.1% TFA .

The experimental results of example 2 are graphically displayed in Fig. 1. Fig. 1 compares the mass spec chromatograms of Tubes 1, 2, and 3 against an untreated human plasma sample diluted 1:30 with 1X PBS, which serves as control. In both tube 1 (magnetic particles + anti-human albumin) and tube 2 (magnetic particles + anti-human IgG1), at least six distinct peaks are resolved that are either not detectable in the control sample or barely rise above the noise associated with the chromatogram baseline. The six peaks appear in the form of two relatively small molecular weight proteins (1), (2) between 5 and 10,000 Da and four larger proteins (3), (4), (5) and (6) at approximately 15,000 (peaks (3) and (4)), 20,000 and 26,000 Da. This pattern remains consistent in the chromatogram for tube 3 (magnetic

particles + anti-human albumin + anti-human IgG1), which also shows six additional well-resolved peaks.

5 The resolution of additional protein peaks indicates that treating human plasma samples with magnetic particles containing anti-albumin and/or anti-IgG prior to mass spectrometry, can enhance detection of other proteins of potential interest. Use of these particles on an automated system proven to effectively manipulate magnetic particles and fluids, would enable high throughput automated sample preparation for mass spectrometry.

10 The foregoing presentation of the described embodiments is provided to enable any person skilled in the art to make or use the present invention. Various modifications to these embodiments are possible, and the generic principles presented herein may be applied to other embodiments as well. The abstract is not to be construed as limiting the scope of the present invention, as its purpose is to enable the appropriate authorities, as well as the general public, to quickly determine the general nature of the invention.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method for isolating a target compound from a sample comprising:
 - a) adding at least one paramagnetic particle comprising: a metal selected from the group consisting of iron, cobalt and nickel; a metallic compound chosen from the group consisting of iron oxide, iron sulfide, iron chloride, ferric hydroxide, and ferrosferric oxide; and an organometallic compound, to a sample comprising one or more target compounds selected from the group consisting of an antibody, a haptan, an enzyme, a polypeptide, and a protein, wherein the at least one paramagnetic particle has additionally attached to said paramagnetic particle one or more ligands or functional groups, wherein said ligand or functional groups have an affinity for one or more of the target compounds in the sample;
 - b) contacting the one or more ligands or functional groups with the one or more target compounds to form a complex;
 - c) immobilizing the complex by applying a magnetic field;
 - d) removing the portion of the sample not immobilized by the magnetic field;
 - e) removing the magnetic field to release the complex;
 - f) eluting the target compounds from said complex;
 - g) immobilizing the paramagnetic particles; and
 - h) retrieving the target compounds.
2. The method of claim 1, wherein the one or more ligands or functional groups are covalently bound to the at least one paramagnetic particle.
3. The method of claim 1, wherein the one or more ligands or functional groups are specific for the target compound.
4. The method of any one of the preceding claims, wherein the one or more ligands or functional groups are attached through biological linkages.
5. The method of claim 4, wherein the biological linkages are selected from the group consisting of streptavidin-biotin, avidin-biotin, carbohydrates-lectins, and enzyme- enzyme inhibitors.
6. A method for isolating a target compound from a sample comprising one or more target compounds and compounds not of interest, the method comprising:
 - a) adding at least one paramagnetic particle to a sample comprising one or more target compounds, wherein said paramagnetic particle has additionally attached to said paramagnetic particle one or more ligands or functional groups wherein said one or more ligands or functional groups having an affinity for one or more of target compounds not of interest in said sample, said target compound not of interest is

selected from the group consisting of an antibody, a hapten, an enzyme, a polypeptide, and a protein;

b) contacting the ligands or functional groups with the compounds not of interest to form a complex;

5 c) immobilizing the complex by applying a magnetic field; and

d) removing the portion of the sample not immobilized by the magnetic field, wherein the sample thus removed contains the one or more target compounds.

7. The method of claim 6, wherein the one or more ligands or functional groups are covalently bound to the paramagnetic particle.

10 8. The method of claim 6 or claim 7, wherein said one or more ligands or functional groups are specific for the target compound not of interest.

9. A method of any one of claims 6 to 8, wherein the at least one paramagnetic particle is a metal selected from the group consisting of iron, cobalt, and nickel.

15 10. A method of any one of claims 6 to 8, wherein the at least one paramagnetic particle is an iron compound selected from the group consisting of iron oxide, iron sulfide, iron chloride, ferric hydroxide and ferrosferric oxide.

11. The method of claim 6, wherein the one or more ligands or functional groups are attached through biological linkages.

20 12. The method of claim 11, wherein the biological linkages are selected from the group consisting of streptavidin-biotin, avidin-biotin, carbohydrates-lectins, and enzyme- enzyme inhibitors.

13. A method for isolating compounds from a sample, the method comprising:

25 a) adding at least one paramagnetic particle to a sample comprising one or more target compounds selected from the group consisting of an antibody, a hapten, an enzyme, a polypeptide, and a protein, wherein the at least one paramagnetic particle and the one or more target compounds have a charge difference;

b) generating a complex between the one or more target compounds and the at least one paramagnetic particle;

30 c) immobilizing the complex by applying a magnetic field;

d) separating the complex immobilized by the magnetic field from the sample;

e) removing the magnetic field to release the complex;

f) eluting said target compounds from the complex;

g) immobilizing said paramagnetic particles; and

h) retrieving the target compounds.

14. The method of claim 13 , wherein the at least one paramagnetic particle has one or more charged functional groups attached thereto to provide the at least one paramagnetic particle with an overall charge.
15. The method of claim 13 or claim 14 , further comprising the steps of
5 centrifuging, filtration, purifying via affinity chromatography and resolving the complex prior to applying the magnetic field.
16. The method of any one of claims 13 to 15, wherein the sample is altered by changing the sample pH.
17. The method of any one of claims 13 to 15, wherein the sample is altered by
10 changing the ionic strength.
18. The method of claim 14, wherein the at least one paramagnetic particle is a metal selected from the group consisting of iron, cobalt, and nickel.
19. The method of claims 13, wherein the at least one paramagnetic particle is an
15 iron compound selected from the group consisting of iron oxide, iron sulfide, iron chloride, ferric hydroxide and ferrosferric oxide.

FIG. 1

