allow for the removal of the sample fluid. However, the fixed-field magnets used in conventional magnetic sample plate applications are not capable of achieving robust mixing. For example, the magnetic particles generally tend to aggregate and cluster in discrete areas of the sample wells. The magnetic particles move with the liquid through small turbulent areas when using traditional mixing methods, thus making mixing inefficient. In addition, the plate itself must be moved between steps of the analysis, which requires significant automation.

BRIEF SUMMARY

[0004] Accordingly, a need exists to improve the overall speed and efficiency of sample mixing and separation using magnetic particles, including ultra-fast homogenous mixing of sample fluids. A need also exists for magnetic particles that have a high response to external magnetic fields as well as a low remanence. Furthermore, a need exists for the magnetic particles to remain suspended for a given time after mixing. A need also exists for a mixing method that mixes the magnetic particles through the liquid rather than with the liquid.

[0005] Examples of the invention address these and other challenges, individually and collectively.

[0006] A first aspect of the present invention relates to a non-aggregated magnetic particle for selectively binding and isolating an analyte of interest in a sample~~processing a sample solution~~. The magnetic particle comprises a magnetic material, having a ferrimagnetic core; and a coating surrounding the ferrimagnetic core, the coating including a ligand on the surface of the coating, wherein the ligand is chemically configured to selectively bind to the analyte of interest in the sample, the magnetic particle having an average diameter of at least 100 nm and having a maximum field strength in a range of from ~~about~~ 20 A m^2/kg~~emu/g~~ to ~~about~~ 250 A m^2/kg~~emu/g~~ and a remanence in a range of from ~~about~~ 0 A m^2/kg~~emu/g~~ to ~~about~~ 30 A m^2/kg~~emu/g~~. ~~The magnetic particle further comprises a ligand attached to an outer surface of the magnetic particle. The ligand interacts with an analyte of interest in the sample solution.~~

[0007] Another aspect relates to a method of processing a sample. The method includes providing a non-aggregated magnetic particle for selectively binding and isolating an analyte of interest in a sample, the magnetic particle having a ligand attached to an outer surface of the particle. The ligand interacts with an analyte of interest in the sample. The magnetic particle has a maximum

field strength in a range of from ~~about~~ 20 A m^2/kg~~emu/g~~ to ~~about~~ 250 A m^2/kg~~emu/g~~ and a remanence in a range of from ~~about~~ 0 A m^2/kg~~emu/g~~ to ~~about~~ 30 A m^2/kg~~emu/g~~, the magnetic particle having a ferrimagnetic core; and a coating surrounding the ferrimagnetic core, the coating including a ligand on the surface of the coating, wherein the ligand is chemically configured to selectively bind to the analyte of interest in the sample, the magnetic particle having an average diameter of at least 100 nm. The method further includes contacting a solution comprising the analyte of interest with the magnetic particle to allow the ligand to interact with the analyte of interest.

[0008] Another aspect relates to a method for processing a sample. First, a container comprising ferrimagnetic particles and a sample is provided. The

WHAT IS CLAIMED IS:

1. A non-aggregated magnetic particle for selectively binding and isolating an analyte of interest in a sample~~processing a sample solution~~, the magnetic particle comprising:

a magnetic material, having a ferrimagnetic core; and a coating surrounding the ferrimagnetic core, the coating including a ligand on the surface of the coating, wherein the ligand is chemically configured to selectively bind to the analyte of interest in the sample, the magnetic particle having an average diameter of at least 100 nm and having a maximum field strength in a range of from ~~about~~ 20 ~~emu/g~~A m^2/kg to ~~about~~ 250 A m^2/kg~~emu/g~~ and a remanence in a range of from ~~about~~ 0 A m^2/kg~~emu/g~~ to ~~about~~ 30 A m^2/kg~~emu/g; and a ligand attached to an outer surface of the magnetic particle, wherein the ligand interacts with an analyte of interest in the sample solution~~.

~~2. The magnetic particle of claim 1, wherein the magnetic material comprises ferrimagnetic material.~~

~~3~~2. The magnetic particle of ~~any one of~~ claim~~s~~ 1 ~~or 2~~, wherein the magnetic material comprises Fe3O4, Fe2TiO2, FeTiO2, MnFe2O4, NiFe2O4, MgFe2O4, Fe7S8, Fe3S4, FeS, or FeOOH.

~~4~~3. The magnetic particle of ~~any one of~~ claim~~s~~ 1 ~~3~~ or 2, wherein the ligand comprises a thiol group, streptavidin, an amine group, a hydroxyl group, a tosyl group, an epoxy group, an alkyl group, a vinyl group, an aryl group, an enzyme, a protein, a deoxyribonucleic acid, a ribonucleic acid, an immunoglobulin G, a carboxyl group, or a monoclonal antibody.

~~5~~4. The magnetic particle of any one of claims 1-~~4~~3, wherein the ligand comprises a carboxyl group.

~~6~~5. The magnetic particle of any one of claims 1-~~5~~4, wherein the maximum field strength is in a range of from ~~about~~ 35 A m^2/kg~~emu/g~~ to ~~about~~ 100 A m^2/kg~~emu/g~~.

~~7~~6. The magnetic particle of any one of claims 1-~~6~~5, wherein the remanence is in a range of from ~~about~~ 0 A m^2/kg~~emu/g~~ to ~~about~~ 10 A m^2/kg~~emu/g~~.

~~8~~7. A method of processing a sample, the method comprising:

providing a non-aggregated magnetic particle for selectively binding and isolating an analyte of interest in a sample, the magnetic particle having a ligand attached to an outer surface of the particle, wherein the ligand interacts with an analyte of interest in the sample, the magnetic particle having a maximum field strength in a range of from ~~about~~ 20 A m^2/kg~~emu/g~~ to ~~about~~ 250 A m^2/kg~~emu/g~~ and a remanence in a range of from ~~about~~ 0 A m^2/kg~~emu/g~~ to ~~about~~ 30 A m^2/kg~~emu/g~~, the magnetic particle having a ferrimagnetic core; and a coating surrounding the ferrimagnetic core, the coating including a ligand on the surface of the coating, wherein the ligand is chemically configured to selectively bind to the analyte of interest in the sample, the magnetic particle having an average diameter of at least 100 nm; and

contacting a solution comprising the analyte of interest with the magnetic particle to allow the ligand to interact with the analyte of interest.

~~9~~8. The method of claim ~~8~~7, further comprising subjecting the magnetic particle to a magnetic field, thereby allowing the magnetic particle to be separated from the solution.

~~10~~9. The method of ~~any one of~~ claim~~s~~ ~~8~~ 7 or ~~9~~8, wherein the analyte of interest is a nucleic acid.

~~11~~10. The method of any one of claims ~~8~~7-~~10~~9, wherein the maximum field strength is in a range of from ~~about~~ 35 A m^2/kg~~emu/g~~ to ~~about~~ 100 A m^2/kg~~emu/g~~.

~~12~~11. The method of any one of claims ~~8~~7-~~11~~10, wherein the remanence is in a range of from ~~about~~ 0 A m^2/kg~~emu/g~~ to ~~about~~ 10 A m^2/kg~~emu/g~~.

~~13. The method of any one of claims 8-12, wherein the magnetic particle comprises ferrimagnetic material.~~

~~14~~12. The method of any one of claims ~~8~~7-~~13~~11, wherein the magnetic particle comprises Fe3O4, Fe2TiO2, FeTiO2, MnFe2O4, NiFe2O4, MgFe2O4, Fe7S8, Fe3S4, FeS, or FeOOH.

~~15~~13. The method of any one of claims ~~8~~7-~~14~~12, wherein the ligand comprises a thiol group, streptavidin, an amine group, a hydroxyl group, a tosyl group, an epoxy group, an alkyl group, a vinyl group, an aryl group, an enzyme, a protein, a deoxyribonucleic acid, a ribonucleic acid, an immunoglobulin G, a carboxyl group, or a monoclonal antibody.

~~16~~14. The magnetic particle of claim 1, further comprising a coating layer enclosing the magnetic particle.

~~17~~15. The magnetic particle of claim ~~16~~14, wherein the coating layer comprises silica.