CLAIMS

1. A system operable to synthesize nanoparticles, the system comprising:

a robotic module comprising:

a temperature controller;

one or more dispensers operable to dispense different reagents; and

an extraction device;

a reaction vessel configured to receive the different reagents directly from the one or more dispensers to form a reaction mixture from which the nanoparticles are synthesized; and

a process control module operably coupled to the robotic module and a spectroscopy module, wherein the process control module configures:

the extraction device to withdraw a sample of the reaction mixture from the reaction vessel at an interval as the reaction mixture progresses and to transfer the sample into one or more cuvettes of the spectroscopy module, and

the spectroscopy module to generate spectral data based on an optical property of the sample and from the spectral data identify a condition which serves as a feedback to the process control module to configure:

the temperature controller to change or maintain temperature of the reaction mixture as the reaction mixture progresses,

the one or more dispensers to change or maintain a frequency and/or time and/or an amount of each different reagent dispensed into the reaction mixture as the reaction mixture progresses, and

the extraction device to change or maintain the interval for withdrawing further samples of the reaction mixture to provide the feedback continuously to have the process control module configure the temperature controller, the one or more dispensers, and the extraction device, in aforesaid manner until synthesis of the nanoparticles in the reaction mixture is completed.

2. The system of claim 1, wherein the robotic module further comprises a heating stage for a heating vessel to be arranged thereon, wherein the heating stage comprises a heating element, wherein the heating element is operably coupled to the temperature controller to adjust heat provided from the heating element to the reaction mixture.

3. The system of claim 2, wherein the heating vessel houses an oil bath.

4. The system of any one of claims 1 to 3, wherein the robotic module comprises a rotatably adjustable receptacle to position the reaction vessel in the heating vessel.

5. The system of any one of claims 1 to 4, wherein the one or more dispenser comprises:

one dispenser to dispense a solvent;

one dispenser to dispense a polymeric precursor; and

one dispenser to dispense a metal precursor.

6. The system of claim 5, wherein the one dispenser for dispensing the solvent is operable to dispense the solvent into the one or more cuvettes.

7. The system of any one of claims 1 to 6, wherein the extraction device comprises a suction pump connected to a tube, and the extraction device is operably coupled to a fan which is operable to dry the tube.

8. The system of any one of claims 1 to 7, wherein the spectroscopy module comprises:

a rack to house the one or more cuvettes;

a light source configured to project light toward the one or more cuvettes;

a detector configured to received light projected through the sample in the one or more cuvettes; and

a data acquisition module operably coupled to the process control module, wherein the data acquisition module converts light received by the detector into spectral data.

9. The system of any one of claims 1 to 8, wherein the process control module is operable to have each of the one or more dispensers dispense the different reagents in a dropwise or single-shot manner.

10. A method of synthesizing nanoparticles using the system of any one of claims 1 to 9, the method comprising:

providing a reaction mixture from which the nanoparticles are synthesized directly in the reaction vessel;

having the process control module configure the extraction device to withdraw a sample of the reaction mixture from the reaction vessel at an interval as the reaction mixture progresses and to transfer the sample into one or more cuvettes of the spectroscopy module;

generating spectral data from the spectroscopy module based on an optical property of the sample;

identifying from the spectral data a condition which serves as a feedback to the process control module; and

having the process control module, based on the feedback, configure:

the temperature controller to change or maintain temperature of the reaction mixture as the reaction mixture progresses,

the one or more dispensers to change or maintain a frequency and/or time and/or an amount of each different reagent dispensed into the reaction mixture as the reaction mixture progresses, and

the extraction device to change or maintain the interval for withdrawing further samples of the reaction mixture to provide the feedback continuously to have the process control module configure the temperature controller, the one or more dispensers, and the extraction device, in aforesaid manner until synthesis of the nanoparticles in the reaction mixture is completed.

11. The method of claim 10, wherein prior to providing the reaction mixture, further comprises providing the oil bath in a heating vessel and having the robotic module operably configure a rotatably adjustable receptacle to position the reaction vessel in the heating vessel.

12. The method of claim 11, wherein prior to providing the reaction mixture, further comprises heating the oil bath to 150°C to 250°C.

13. The method of any one of claims 10 to 12, wherein providing the reaction mixture comprises operating the one or more dispensers to dispense each different reagent at one or more specified times directly into the reaction vessel, wherein operating the one or more dispensers comprises:

having one dispenser to dispense a solvent;

having one dispenser to dispense a polymeric precursor; and

having one dispenser to dispense a metal precursor.

14. The method of claim 13, wherein having the one dispenser to dispense the polymeric precursor comprises dissolving the polymeric precursor in an organic solvent.

15. The method of claim 13 or 14, wherein operating the one or more dispensers to dispense the different reagents comprises:

adding the polymeric precursor before adding the metal precursor but after loading the solvent into the reaction vessel.

16. The method of any one claims 10 to 15, wherein having the process control module configure the extraction device to withdraw the sample comprises:

operating the suction pump to withdraw a sample of the reaction mixture via a tube positioned in reaction vessel and having the suction pump deliver the sample into the one or more cuvettes; and

operating the fan coupled to the extraction device to dry the tube after the extraction device delivers the sample.

17. The method of any one of claims 10 to 16, wherein generating spectral data from the spectroscopy module based on an optical property of the sample comprises:

projecting a light toward the one or more cuvettes;

having the detector configured to receive the light projected through the sample in the one or more cuvettes; and

having the data acquisition module convert the light received by the detector into spectral data.

18. The method of any one of claims 10 to 17, wherein having the process control module, based on the feedback, configure the one or more dispensers to change or maintain a frequency and/or time and/or an amount of each different reagent dispensed into the reaction mixture as the reaction mixture progresses comprises:

having the process control module configure each of the one or more dispensers to dispense the different reagents in a dropwise or single-shot manner.

19. The method of any one of claims 10 to 18, wherein the optical property comprises color of the sample.

20. The method of any one of claims 10 to 19, wherein identifying from the spectral data the condition which serves as the feedback to the process control module comprises:

identifying a first wavelength and/or a second wavelength which correspond to a first peak and/or a second peak in the spectral data, respectively; and/or

identifying any change in the first wavelength and/or second wavelength from the further samples as the reaction mixture progresses to determine completion of synthesis of the nanoparticles in the reaction mixture.