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High T_c SQUID system for biological immunoassays

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A high T_c SQUID system is developed for the application to biological immunoassay. In this application, magnetic nanoparticles are used as magnetic markers to perform immunoassay, i.e., to detect binding reaction between an antigen and its antibody. The antibody is labeled with γ-Fe_2O_3 (or Fe_3O_4) nanoparticles, and the binding reaction can be magnetically detected by measuring the magnetic field from the nanoparticles. Design and set up of the system is described. The system consists of (1) SQUID magnetometer or gradiometer made of 30-deg. bicrystal junctions, (2) field and compensation coils to apply the magnetic field of about 1 mT, (3) special Dewar to realize a 2 mm-distance between the SQUID and the sample, (4) two layers of cylindrical shielding to reduce the external magnetic noise to about 1/100, and (5) an electric slider to move the sample with a speed of 10 mm/sec. The sensitivity of the system is studied in terms of detectable magnetic flux. For the measurement bandwidth from 0.2 Hz to 10 Hz, minimum-detectable amplitude of the magnetic flux is 0.8 m Φ_0 and 0.25 mΦ_0 for the magnetometer and the gradiometer, respectively, when the magnetic field of 1 mT is applied. The difference between them is due to the residual environmental noise, and the applied magnetic field does not increase the system noise. The corresponding weight of the magnetic markers is 1 ng and 310 pg, respectively. An experiment is also conducted to measure antigen-antibody reaction with the present system. It is shown that the sensitivity of the present system is 10 times better than that of the conventional method using an optical marker. A one order of magnitude improvement of sensitivity will be realized by the sophistication of the present system.