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ORIGINAL PAPER

Biocompatibility of Fe_2O_3 Nanoparticles for the Activation of Glia Cell Migration

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Abstract We study the biocompatibility, the magnetic clustering, and the possible transfection effect of iron particles on glia cells. Results indicate that iron particles can coexist quite well with glia cells, and the inductive migration of the cell through the vanishing of the Fe compound particles around the cell is examined. Transfection experiments also prove the feasibility of using iron particles with glia cells.

Keywords Glia cell · Biocompatibility

1 Introduction

For the past few years, research on iron particles for biomedical purposes has been proposed and investigated [1–5]. The passive and active targeting of the nanoparticles provides a promising application to materials science. These techniques have been applied to various kinds of cells. To study the potential application of the Fe_2O_3 particles for neural growth, we introduce glia cells (from the mouse) in the present study. It is well known that the glia cells are the supporting structure for the central nervous system, and they number vastly greater than neuron cells, which are responsible for sending and receiving signals. Therefore, an understanding of the effects of cations and small particles on the glia cell is of significant meaning to the bioscientist. In the following sections, we will focus on the biocompatibility and the magnetic induction of these particles to the glia cell. An experiment for injecting the particles into the cell is under investigation.

2 Materials and Methods

We incubate glia cells of the mouse with part of the stem cell at 37.5 °C, and the cell count is 97,800 cells. The sizes of the Fe particles are prepared as 50 nm. However, after mixing with the medium, a clustering Fe_2O_3 morphology is mostly expected. The molecular mass of Fe_2O_3 is 159.692 g/mole. Components of the medium (total volume 520 ml) are DMEM (12800-017, GIBCO) 450 ml, fetal bovine serum 50 ml, penicillin/streptomycin (15140-122, GIBCO) 5 ml, nonessential amino acid solution (M7145, Sigma) 5 ml, sodium pyruvate 5 ml. The stock concentration becomes 7.5 micrograms. The incubation platform is a 35 mm Corning CellBIND®Surface Culture Dish.

We proceed with three experiments to study the feasibility of the Fe particles. The first one is the biocompatibility experiment to control the incubation time (T) and the concentration (C) of the particle/medium mixtures. The media supplied are carefully treated to maintain stabilized conditions for each factor experiment. Particles will cluster together to form larger entities in the medium. After confirming the biocompatibility of the particles with glia cells, the magnetic field inductive migration experiment is performed as the second experiment. Figure 1 shows the system layout.

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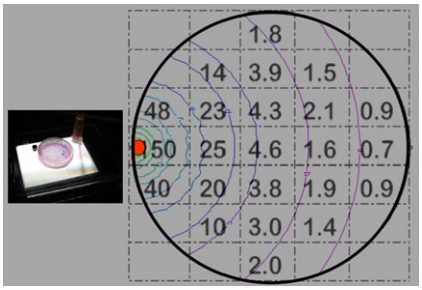


Fig. 1 Magnetic field inside the incubator (units of numerical value in gauss, by Gauss/Teslameter (F.W. Bell Model 5070)

Table 1 Experiment results for Fe_2O_3 biocompatibility

T (days)	C		
	25X	50X	100X
3	++	+	++
7	+	+	++
10	+	+	+

A magnetic source is placed near the incubator disk. The numerical value (units in gauss) is the magnetic flux measured by the Gauss/Teslameter (F.W. Bell Model 5070).

Biological effects within the magnetic field are to be observed. After that, the third experiment is the particle transfection. Nucleofector technology from AMAXA[1] is a transfection technology especially designed for the needs of difficult-to-transfect cell lines, and is based on a unique combination of electrical parameters and cell-type-specific solutions. We try to use this transfection technology to drive the iron particles into the glia cell and observe the possible effects.

3 Results and Discussion

For the biocompatibility experiments, Table 1 lists the results for different incubation times T and particle concentrations C. Note that 25X (2 mM), 50X (1 mM) and 100X (0.5 mM) indicate the diluted ratio compared with the stock concentration (0.05 M).

Symbol "+" indicates that the cell can coexist well with the Fe_2O_3 particles. Figure 2 shows the images for 25X concentration with different incubation times. It is clear that the particles will accumulate on the surface of the cell. This verifies the first biocompatibility experiment of the Fe_2O_3 particles.

Concerning the magnetic induction experiments, the magnetic field is supposed to form a torque and a force

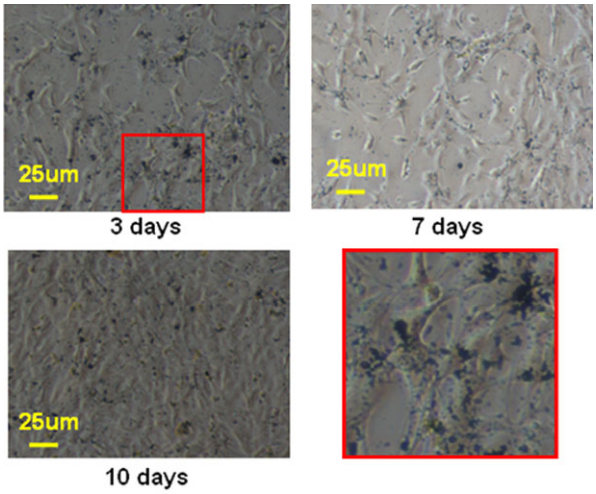
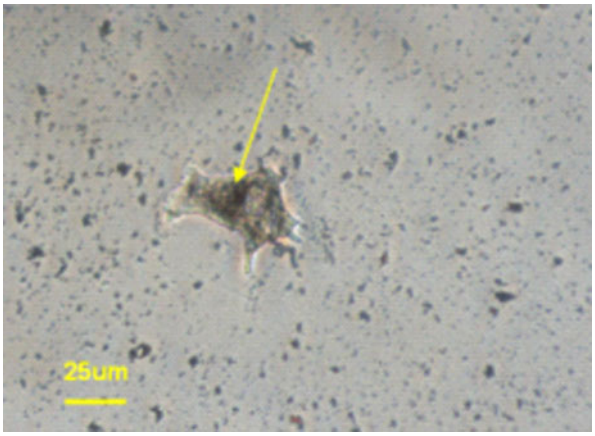
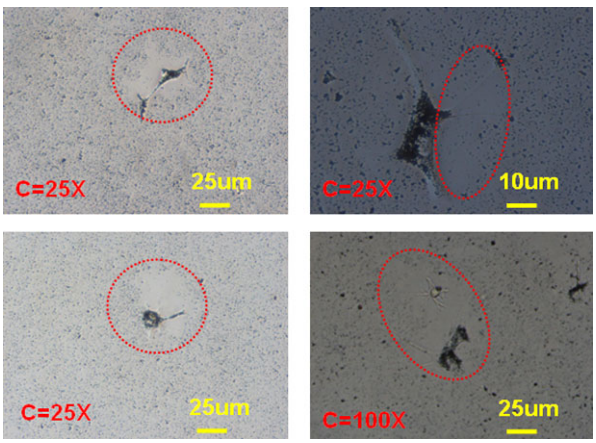


Fig. 2 Biocompatibility of Fe_2O_3 particles with glia cell



(a) Particles within cells under C=5X concentration and 6 days

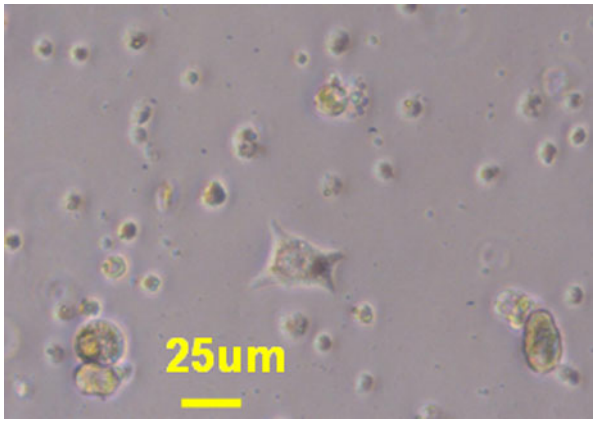


(b) Particles disappear around the cells

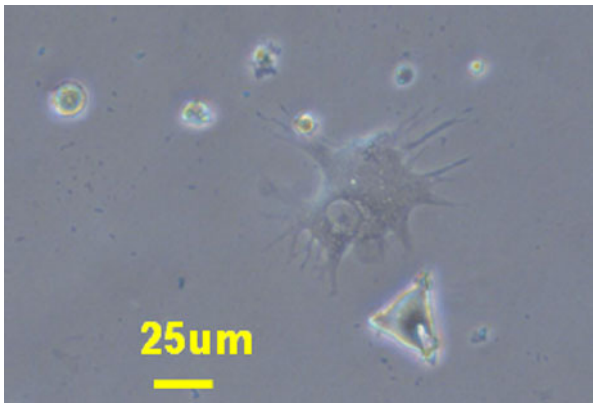
Fig. 3 Magnetic induction experiments

on the cell surface. However, we have used a 400 gauss magnetic flux act on the incubator and realize that it cannot produce significant migration of the cell. In spite of this, the

[1] http://www.amaxa.com/extras/mailings/basic-nucleofectorsuprsup-kits/.



(a) Glia cell conditions after 9 hours



(b) Glia cell conditions after 4 days

Fig. 4 Transfection experiment using Fe_2O_3 particles with glia cell

particles can be guided by the magnetic field to attach on the surface of the cell. Furthermore, we found that parts of the particle might penetrate into the cell under a longer incubation time. Figure 3(a) gives the images for 5X concentration after a 16-day-long incubation. Also, it is interesting to see that there exist clearing regions such that the numbers of particles vanish around the bodies of the cells under different concentrations.

The locations of these cells are arbitrary in the incubators, indicating that this is an overall phenomenon. The magnetic source is located on the left side for all these images, and no such phenomenon occurs if there is no magnetic source (Fig. 2). Therefore, the interaction of the particles carried by the cell results in a more complicated interaction mode with the magnetic field, which required further investigation.

As for the transfection experiments, results indicate that the Fe_2O_3 particles might result in damage to the cell. However, some part of the glia cell is still alive after the transfection procedures. The control experiment (without the particles) had verified that all the glia cells are under normal morphology in the incubation system. The primitive conjecture is that the Fe_2O_3 particles will interact with the membrane of the glia cells. We compare the results after 9 hours and after 4 days, and confirm that the glia cell can survive after the transfection operation (see Fig. 4). On the other hand, the effect of the magnetic field on the iron particles is basically in a creeping mode; therefore, there is no biological damage from the magnetic field to the cells.

4 Conclusion

We report that Fe_2O_3 particles are robust materials for the three biophysics applications: biocompatibility, magnetic induction, and transfection of the particles to the glia cell. We also observe that part of the stem cell can coexist well in an environment that is full of Fe_2O_3 particles. This encourages us to think that the Fe_2O_3 material could serve as a feasible carrier for stem cell targeting experiments in the future.

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