TRANSFECTION REAGENTS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 12/353,371 filed Jan. 14, 2009, which application is a continuation of U.S. application Ser. No. 11/040,687, filed Jan. 21, 2005, now U.S. Pat. No. 7,479,573, which is a continuation of U.S. application Ser. No. 09/438,365, filed Nov. 12, 1999, now U.S. Pat. No. 7,166,745, which claims the benefit under 35 U.S.C. §119(e) of U.S. provisional application Ser. No. 60/108,117, filed Nov. 12, 1998, the disclosures of which applications are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

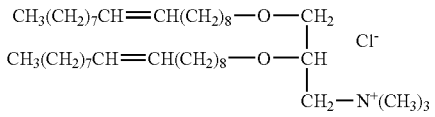
The present invention relates to cationic lipids and compositions of cationic lipids having utility in lipid aggregates for delivery of macromolecules and other compounds into cells.

2. Related Art

Lipid aggregates such as liposomes have been found to be useful as agents for delivery to introduce macromolecules, such as DNA, RNA, protein, and small chemical compounds such as pharmaceuticals, to cells. In particular, lipid aggregates comprising cationic lipid components have been shown to be especially effective for delivering anionic molecules to cells. In part, the effectiveness of cationic lipids is thought to result from enhanced affinity for cells, many of which bear a net negative charge. Also in part, the net positive charge on lipid aggregates comprising a cationic lipid enables the aggregate to bind polyanions, such as nucleic acids. Lipid aggregates containing DNA are known to be effective agents for efficient transfection of target cells.

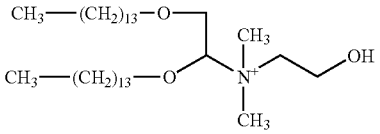
The structure of various types of lipid aggregates varies, depending on composition and method of forming the aggregate. Such aggregates include liposomes, unilamellar vesicles, multilameller vesicles, micelles and the like, having particular sizes in the nanometer to micrometer range. Methods of making lipid aggregates are by now well-known in the art. The main drawback to use of conventional phospholipid containing liposomes for delivery is that the material to be delivered must be encapsulated and the liposome composition has a net negative charge which is not attracted to the negatively charged cell surface. By combining cationic lipid compounds with a phospholipid, positively charged vesicles and other types of lipid aggregates can bind DNA, which is negatively charged, can be taken up by target cells, and can transfect target cells. (Felgner, P. L. et al. (1987) Proc. Natl. Acad. Sci. USA 84:7413-7417; Eppstein, D. et al., U.S. Pat. No. 4,897,355.)

A well-known cationic lipid is N-[1-(2,3-dioleoyloxy)propyl]-N,N,N-trimethylammonium chloride (DOTMA). The structure of DOTMA is:

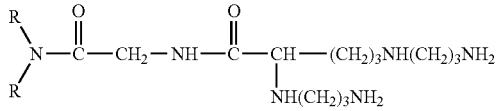


DOTMA by itself or in 1:1 combination with dioleoylphosphatidylethanolamine (DOPE) is formulated into liposomes using standard techniques. Felgner, et al. supra demonstrated that such liposomes provided efficient delivery of nucleic acids to some types of cells. A DOTMA:DOPE (1:1) formulation is sold under the trade name LIPOFECTIN (Life Technologies, Inc., Rockville, Md.). Another commercially available cationic lipid is 1,2-bis(oleoyloxy)-3-3-(trimethylammonia) propane (DOTAP), which differs from DOTMA only in that the oleoyl moieties are linked via ester, rather than ether bonds to the propylamine. A related group of compounds differ from DOTMA and DOTAP in that one of the methyl groups of the trimethylammonium group is replaced by a hydroxyethyl group. Compounds of this type are similar to the Rosenthal Inhibitor (RI) of phospholipase A (Rosenthal, A. F. and Geyer, R. P. (1960) J. Biol. Chem. 235:2202-2206) which has stearoyl esters linked to the propylamine core. The dioleoyl analogs of RI are commonly abbreviated as DORI-ether and DORI-ester, depending on the linkage of the fatty acid moieties to the propylamine core. The hydroxy group can be used as a site for further functionalization.

The dimyristyloxy analog of RI is known as DRMIE. A 1:1 (M/M) DMRIE:cholesterol formulation is sold under the tradename DMRIE-C (Life Technologies, Inc., Rockvilee, Md.). The structure of DMRIE is:

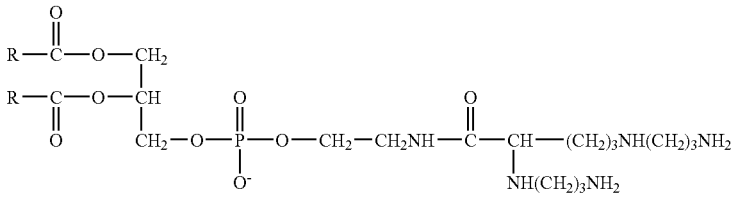


Another class of compounds has been disclosed by Behr et al. (1989) Proc. Natl. Acad. Sci. USA 86:6982-6986; EPO publication 0 394 111 (Oct. 24, 1990), in which carboxyspermine has been conjugated to two types of lipids. The structure of 5-carboxyspermylglycine dioctadecylamide (DOGS) is:



R = $CH_2(CH_2)_{17}$

The structure of dipalmitoylphosphatidylethanolamine 5-carboxyspermylamide (DPPES) is:



R = $CH_3(CH_2)_{15}$