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SZABO-SCANDIC HandelsgmbH

Quellenstraße 110, A-1100 Wien

T. +43(0)1 489 3961-0

F. +43(0)1 489 3961-7

mail@szabo-scandic.com

www.szabo-scandic.com

linkedin.com/company/szaboscandic

Lipid Nanoparticle (LNP-102) Uptake Kit (Green Fluorescence)

Item No. 38218

www.caymanchem.com
Customer Service 800.364.9897
Technical Support 888.526.5351
1180 E. Ellsworth Rd · Ann Arbor, MI · USA

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GENERAL INFORMATION

Materials Supplied

Item Number	Item Name	Quantity/Size	Storage Temperature
33474	SM-102	1 vial/25 mg	-20°C
15100	1,2-Distearoyl-*sn*-glycero-3-PC	1 vial/10 mg	-20°C
9003100	Cholesterol	1 vial/25 mg	-20°C
33945	DMG-PEG(2000)	1 vial/5 mg	-20°C
24618	BODIPY 480/508-Cholesterol	1 vial/1 mg	-20°C

If any of the items listed above are damaged or missing, please contact our Customer Service department at (800) 364-9897 or (734) 971-3335. We cannot accept any returns without prior authorization.

WARNING: THIS PRODUCT IS FOR RESEARCH ONLY - NOT FOR HUMAN OR VETERINARY DIAGNOSTIC OR THERAPEUTIC USE.

Safety Data

This material should be considered hazardous until further information becomes available. Do not ingest, inhale, get in eyes, on skin, or on clothing. Wash thoroughly after handling. Before use, the user must review the complete Safety Data Sheet, which has been sent *via* email to your institution.

Precautions

Please read these instructions carefully before beginning this assay.

If You Have Problems

Technical Service Contact Information

Phone: 888-526-5351 (USA and Canada only) or 734-975-3888

Email: techserv@caymanchem.com

In order for our staff to assist you quickly and efficiently, please be ready to supply the lot number of the kit (found on the outside of the box).

Storage and Stability

This kit will perform as specified if stored as directed in the Materials Supplied section (see page 3) and used before the expiration date indicated on the outside of the box.

Materials Needed But Not Supplied

1. Absolute ethanol
2. 50 mM sodium acetate, pH 5.0
3. Nucleic acid payload *NOTE: GFP mRNA is incompatible with this kit due to fluorescence of BODIPY.*
4. Commercial microfluidic device, off-the-shelf microfluidic device, extrusion kit, or sonicator
5. PBS, pH 7.4

INTRODUCTION

Background

Lipid nanoparticles (LNPs) are a subset of lipid-based drug delivery (LBDD) systems that utilize ionizable lipids, such as SM-102, for the delivery of nucleic acid (*e.g.* siRNA, mRNA, cyclic dinucleotides) payloads to cells.[1] They consist of a lipid shell composed of structural phospholipids, cholesterol, and PEGylated lipids that surround an internal aqueous core, where the ionizable lipids organize into inverted micelles around the encapsulated nucleic acids.[2] Ionizable lipids are near-neutral at physiological pH and cationic in acidic environments (theoretical pK_a for SM-102 = 6.75), a property that promotes the encapsulation of negatively charged nucleic acids during LNP preparation and facilitates intracellular delivery after cellular uptake.[1,3] LNPs are internalized into cells *via* endocytosis.[4] SM-102 becomes protonated and positively charged in the acidic environment of the endosomal compartment, promoting LNP endosomal escape and intracellular delivery.[5]

Cayman's Lipid Nanoparticle (LNP-102) Uptake Kit (Green Fluorescence) is intended to serve as a starting point for laboratories to explore the uptake of LNPs by their target cell type without the need for specialized equipment. Optimal preparation conditions for the encapsulation of nucleic acids with LNPs must be determined by the end user. Adjustment of the following parameters may facilitate this process:

- Lipid molar ratio
- Lipid:nucleic acid (w:w) ratio
- Ionizable lipid nitrogen:nucleotide phosphate (N:P) molar ratio
- Aqueous buffer: identity and ionic strength
- Particle size: extrusion size or microfluidic operating parameters, as applicable
- LNP preparation method

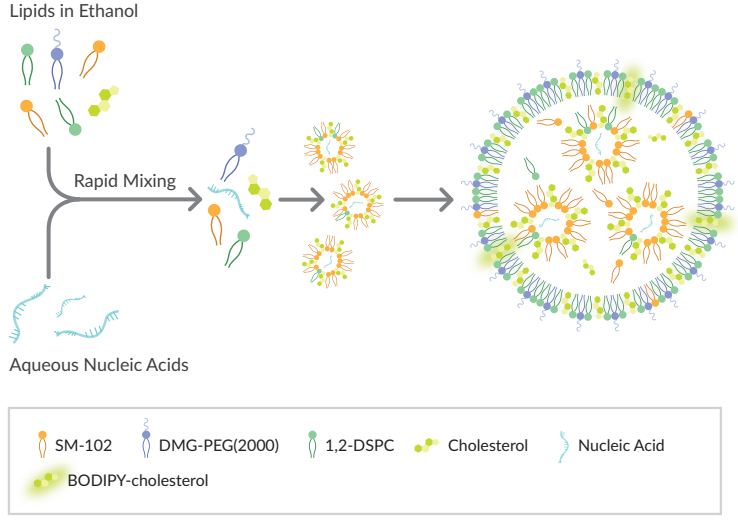

Figure 1. Schematic of Nucleic Acid-Containing LNP Formation with Lipid Nanoparticle (LNP-102) Uptake Kit (Green Fluorescence)

PROTOCOL PREPARATION

Protocol

An example for preparing nucleic acid-containing LNPs with an ethanolic lipid mixture containing SM-102 (Item No. 33474), 1,2-distearoyl-*sn*-glycero-3-PC (1,2-DSPC; Item No. 15100), cholesterol (Item No. 9003100), BODIPY-cholesterol (Item No. 24618), and DMG-PEG(2000) (Item No. 33945) at lipid molar ratios of 50:10:36.5:2:1.5, respectively, is shown below. These molar ratios are derived from those used in mRNA-based vaccines. This example is shown with a lipid:nucleic acid (w:w) ratio of 10:1 and an ethanol:aqueous ratio of 1:3. The end user may scale volumes and adjust lipid molar and lipid:nucleic acid ratios as desired. It is possible to produce multiple small batches of LNPs using the parameters in this example and the reagents provided in the kit.

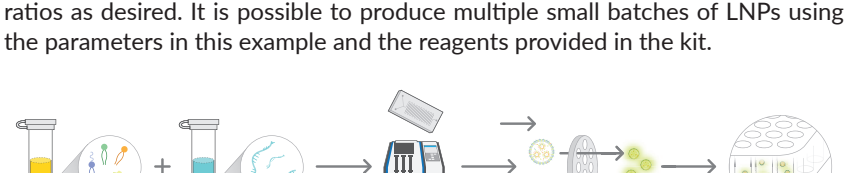

Figure 2. Lipid Nanoparticle (LNP-102) Uptake Kit (Green Fluorescence) Workflow

Reagent Preparation

1. Ethanolic Lipid Mixture

Prepare individual lipid stock solutions of the four lipids supplied as crystalline solids in absolute ethanol. SM-102 is ready to use as supplied. Bring all stock solutions to room temperature prior to use and ensure they are well-dissolved. Transfer the appropriate volume of each lipid mixture component to a single tube as listed in the table below to prepare the ethanolic lipid mixture. Mix by pipetting several times.

Lipid Mixture Component	Stock Solutions		Working Mixture		
	mg/ml	MW	Molar Ratio	mg	Required Volume
SM-102	100	710.2	50.0	3.55	35 µl
1,2-DSPC	25	790.2	10.0	0.79	31 µl
Cholesterol	5	386.7	36.5	1.38	276 µl
DMG-PEG(2000)	1	2,526	1.5	0.38	378 µl
BODIPY-cholesterol	0.6	576.6	2.0	0.14	233 µl
Absolute ethanol					47 µl
Total				6.24	1 ml

Table 1. Preparation of ethanolic lipid mixture

2. Aqueous Nucleic Acid Solution

In a separate tube, bring nucleic acid payload to a concentration of 50-200 µg/ml in 3 ml of 50 mM sodium acetate, pH 5.0. Optimal nucleotide:lipid ratio should be determined empirically for each payload.

PROTOCOL

Performing the Protocol

Several methods are suitable for laboratory-scale, small-volume LNP production. These are described briefly below, and they may be adapted for use with a range of specialized-to-basic equipment. The procedures are performed at room temperature unless otherwise indicated.

1. **Mixing**

   Commercial Microfluidic Device Mixing: Mix the ethanolic lipid mixture with the aqueous nucleic acid solution using a microfluidic device or chip with a staggered herringbone-, T-, or Y-channel design. The inlet flow rates can be controlled with syringe pumps and should be optimized by the end user.

   Off-the-Shelf Microfluidic Device Mixing: Mix the ethanolic lipid mixture with the aqueous nucleic acid solution using an off-the-shelf microfludic mixing device. These mixers can be assembled with common and inexpensive materials. Two inlets, composed of individual syringes containing the ethanolic lipid mixture and the aqueous nucleic acid solution, can be connected to opposite ends of a T- or Y-connector (2 mm I.D.) with appropriate tubing (1.5 mm I.D.) and fittings. A single outlet fitted with the appropriate tubing will direct the LNPs into a collection tube. The inlet flow rates can be controlled with syringe pumps and should be optimized by the end user.

   Solvent-injection Mixing: Rapidly inject the ethanolic lipid mixture into the aqueous nucleic acid solution using a syringe with the needle placed in the center of the solution. Stir at 400 rpm for 30 minutes above the 1,2-DSPC transition temperature (T_m = 55°C).

   Hand Mixing: Hand mix the ethanolic lipid mixture with the aqueous nucleic acid solution *via* pipette by rapidly transferring the ethanolic lipid mixture into the aqueous nucleic acid solution. Mix by repeated pipetting for 15 seconds. Leave undisturbed for 10 minutes.

2. **Final Preparation**

   a. Perform size extrusion if necessary. Size extrusion is typically required following mixing techniques that produce large and heterogenous LNPs (*e.g.* off-the-shelf microfluidic device mixing, solvent-injection, and hand mixing) to yield a narrower LNP size distribution.

   b. Dialyze LNPs in neutral buffer *(e.g.* PBS, pH 7.4) against 1,000 volumes of buffer using the appropriate molecular weight cut-off (MWCO) membrane overnight.

   c. If desired, LNP solutions may be concentrated by centrifugation using the appropriate MWCO filter.

   d. Filter-sterilize LNP solutions with a 0.22 µm filter and store at 4°C until use. The LNP solutions will be stable at 4°C for one week. If longer storage is required, stabilizing reagents such as sucrose may be added for storage at -20°C. Stability testing should be conducted for each LNP formulation method to optimize storage conditions.

3. Characterization and Validation

A variety of techniques are available to characterize LNPs prior to *in vitro* or *in vivo* use. Contact Cayman Services for *in vitro* testing of your LNPs.

Attribute	Assay(s)
Particle size and distribution	Dynamic light scattering (DLS)
Zeta potential	Laser doppler electrophoresis
Lipid quantification and integrity	RP-HPLC, SE-HPLC, IP-HPLC
LNP morphology	Microscopy (cryo TEM, ESEM, AFM)
LNP uptake	Cell-based imaging or fluorescence detection
Translation or knockdown analyses	Cell-based reporter assays, Western blotting

Table 2. LNP attributes and corresponding assays Adapted from Schoenmaker, L., *et al.*[6]

4. Uptake analysis

BODIPY cholesterol incorporated into the LNPs will fluoresce under the same conditions as GFP (excitation 480 nm, emission 525 nm). Dilute prepared LNPs in medium containing serum about 1:100 to 1:500, then add to cells. After 24-48 hours, exchange medium for PBS and image or capture total fluorescence using a plate reader.

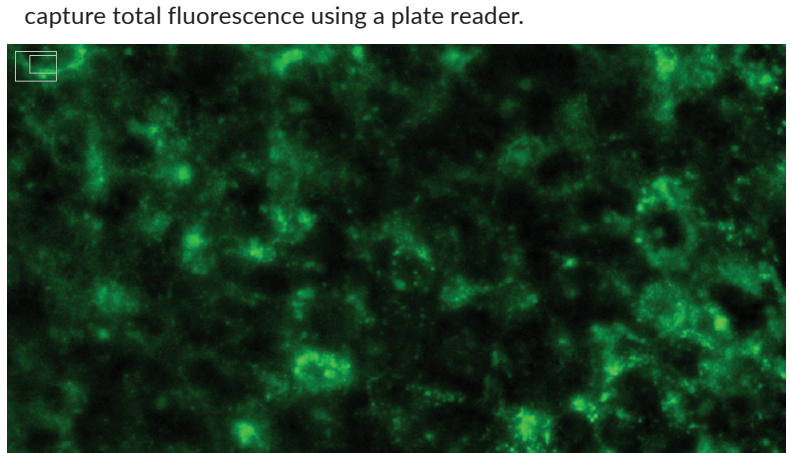

Figure 3. LNP-102 uptake in hepatocytes. LNP-102 was formulated in a Nunchuck device from Unchained Labs, using a flow rate ratio of 3 and a total flow rate of 15 ml/min. After dialysis against PBS, LNPs were diluted 1:200 in cell culture media and added to Huh7 hepatocytes for 48 hours. Imaging was carried out in PBS on a BioTek Cytation 5 imaging plate reader at 20X with a GFP LED/filter cube.

References

1. Mitchell, M.J., Billingsley, M.M., Haley, R.M., *et al.* Engineering precision nanoparticles for drug delivery. *Nat. Rev. Drug Discov.* **20(2)**, 101-124 (2021).
2. Guevara, M.L., Persano, F., and Persano, S. Advances in lipid nanoparticles for mRNA-based cancer immunotherapy. *Front. Chem.* **8**, 589959 (2020).
3. Buschmann, M.D., Carrasco, M.J., Alishetty, S., *et al.* Nanomaterial delivery systems for mRNA vaccines. *Vaccines (Basel)* **9(1)**, 65 (2021).
4. Degors, I.M.S., Wang, C., Rehman, Z.U., *et al.* Carriers break barriers in drug delivery: Endocytosis and endosomal escape of gene delivery vectors. *Acc. Chem. Res.* **52(7)**, 1750-1760 (2019).
5. Carrasco, M.J., Alishetta, S., Alameh, M.-G., *et al.* Ionization and structural properties of mRNA lipid nanoparticles influence expression in intramuscular and intravascular administration. *Commun. Biol.* **4(1)**, 956 (2021).
6. Schoenmaker, L., Witzigmann, D., Kulkarni, J.A., *et al.* mRNA-lipid nanoparticle COVID-19 vaccines: Structure and stability. *Int. J. Pharm.* **601**, 120586 (2021).

NOTES

Warranty and Limitation of Remedy

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