




This item was submitted to Loughborough's Institutional Repository (<https://dspace.lboro.ac.uk/>) by the author and is made available under the following Creative Commons Licence conditions.



CC creative commons
COMMONS DEED

Attribution-NonCommercial-NoDerivs 2.5

You are free:

- to copy, distribute, display, and perform the work

Under the following conditions:

BY: **Attribution.** You must attribute the work in the manner specified by the author or licensor.


Noncommercial. You may not use this work for commercial purposes.

No Derivative Works. You may not alter, transform, or build upon this work.

- For any reuse or distribution, you must make clear to others the license terms of this work.
- Any of these conditions can be waived if you get permission from the copyright holder.

Your fair use and other rights are in no way affected by the above.

This is a human-readable summary of the [Legal Code \(the full license\)](#).

[Disclaimer](#) 

For the full text of this licence, please go to:
<http://creativecommons.org/licenses/by-nc-nd/2.5/>

LIDOCAINE NaCMC:GEL HYDROGEL DELIVERY USING COMBINED MICRONEEDLE AND SONOPHORESIS

Atul Nayak, Tao Han, Diganta Bhusan Das

Chemical Engineering Department, Loughborough University, Loughborough, UK.

(Emails: A.Nayak@lboro.ac.uk; T.Han@lboro.ac.uk; D.B.Das@lboro.ac.uk)

Lidocaine hydrochloride (HCl) is a water soluble weak acidic, local anaesthetic, usually administered by injection into the dermis layer of skin causes pain^{1,2}. Alternatively an eutectic mixture of local anaesthetics (EMLA) may be unsuitable in emergency situations because a 1 hour time duration of permeation is necessary^{3,4}. Low frequency sonophoresis (LFS) within a range of 20-100 kHz allows for the mechanism of inertial cavitation as the accepted theory for enhancing skin permeability^{5,6}. Additionally a minimally invasive mechanism of microneedle assisted delivery of topical drugs produces microconduits to bypass the stratum corneum (SC) layer of skin⁷. Jacketed Franz diffusion cells (FDC) were implemented for ex-vivo skin permeation studies of lidocaine NaCMC/GEL hydrogels post treatment by combined microneedle insertion followed by sonophoresis⁸. A lidocaine GEL to NaCMC mass ratio of 2.66 hydrogel treated with 18W LFS for a 10 minute duration combined with microneedle treatment of 5 minute duration resulted in a 4.8 fold average increase over 30 minutes when compared with LFS or passive diffusion alone. Minimum therapeutic levels of lidocaine HCl at 1.5 $\mu\text{g/ml}$ were crossed after a period of 7 minutes post microneedle insertion of 5 mins and 18 W LFS for GEL to NaCMC mass ratio 2.66. A fairly significant and steady decline in the percentage of lidocaine HCl contained in skin from mass balance determination revealed lidocaine GEL to NaCMC mass ratio of 2.66 to possess 99.7% lidocaine HCl within 3 hours. This is likely caused by lidocaine HCl molecules diffusing faster through cavity formed cellular features in skin before systemic clearance in hypodermis or capillaries. The dispersion trends from zeta potential analysis favour lidocaine HCl GEL to NaCMC mass ratios from 1.6 to 2.3 compared with 2.66 of a lot more agglomeration. Increased GEL to NaCMC mass ratios resulted in fairly significant increases in mean particle size diameters despite polydispersity observed with all GEL to NaCMC mass ratios of lidocaine.

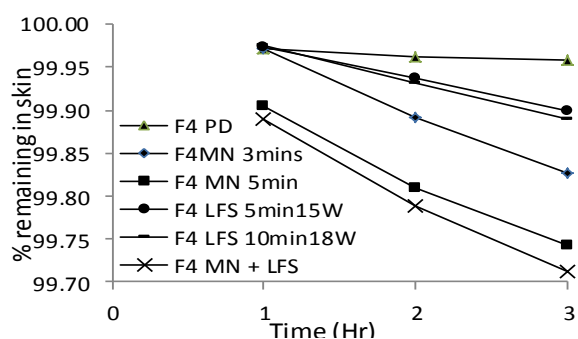


Fig. 1 Example of lidocaine HCl contained in skin from (F4) NaCMC/GEL 1:2.66 (▲ Passive diffusion), (◆ Microneedles, 3 min), (■ Microneedles, 5 min), (● LFS 5 min 15 W), (■ LFS 10 min 18 W), (× Microneedles + LFS)

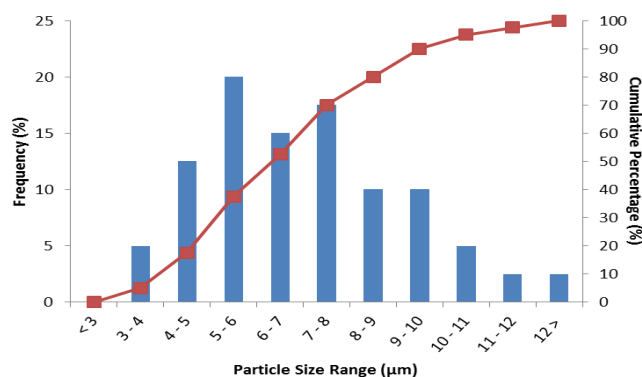


Fig. 2 Example of Particle size distribution of lidocaine NaCMC/gel hydrogels

References

- M.L. González-Rodríguez, L.B. Barros, J. Palma, P.L. González-Rodríguez, A.M. Rabasco "Application of statistical experimental design to study the formulation variables influencing the coating process of lidocaine liposomes" *Pharmaceutical Nanotechnology*, **337**, 336–345 (2007).
- K.B. Colaric, D.T. Overton, K. Moore "Pain reduction in lidocaine administration through buffering and warming" *American Journal of Emergency Medicine*, **16**, 353-356 (1998).
- A. Nayak, D.B. Das "Potential of biodegradable microneedles as a transdermal delivery vehicle for lidocaine" *Biotechnol Lett.*, **35**, 1351-1363 (2013).
- Y. Zhang, K. Brown, K. Siebenaler, A. Determan, D. Dohmeier, K. Hansen "Development of lidocaine coated microneedle product for rapid, safe, and prolonged local analgesic action" *Pharm Res.*, **29**, 170-177 (2012)
- B. Polat, D. Hart, R. Langer, D. Blankschtein "Ultrasound-mediated transdermal drug delivery: mechanisms, scope, and emerging trends" *J Control Release.*, **152**, 330-348 (2011).
- G. Merino, Y.N. Kalia, M.B. Delgado-Charro, R.O. Potts, R.H. Guy "Frequency and thermal effects on the enhancement of transdermal transport by sonophoresis" *J Control Release.*, **88**, 85-94 (2003)
- H.S. Gill, M.R. Prausnitz "Coated microneedles for transdermal delivery" *J Control Release.*, **117**, 227-237 (2007)
- A. Nayak, D.B. Das, G.T. Vladisavljević "Microneedle assisted permeation of lidocaine carboxymethylcellulose with gelatine co-polymer hydrogel" *Pharm. Res.*, **30**, 1-15 (2013)