IX КОНГРЕС ПО ФАРМАЦИЯ
С МЕЖДУНАРОДНО УЧАСТИЕ

PharmaceuticAI Science Revolution

30 ОКТОМВРИ **I**
2 НОЕМВРИ
2025

хотел „Рила”,
Боровец

Българско научно дружество по фармация (БНДФ)

Фармацевтичен факултет при МУ-София

FORMULATION AND PHYSICOCHEMICAL CHARACTERIZATION OF NANOSTRUCTURED LIPID CARRIERS (NLCs) LOADED WITH IBUPROFEN

Borovets
Oct 30–Nov 2
2025

Mihail Aleksandrov, MSc
Ana Alves, PhD
Prof. Viktorija Maksimova, PhD
Prof. Paulo Costa, PhD

Contents

Introduction & Purposes

- Nanostructured Lipid Carriers (NLCs) are advanced, biocompatible drug delivery systems that use a core of mixed solid and liquid lipids to encapsulate drugs, improving their solubility, permeability, and stability.
- An ibuprofen-loaded nanostructured lipid carrier (IBU-NLC) was developed for enhanced skin penetration to improve the treatment of osteoarthritis and other musculoskeletal diseases.

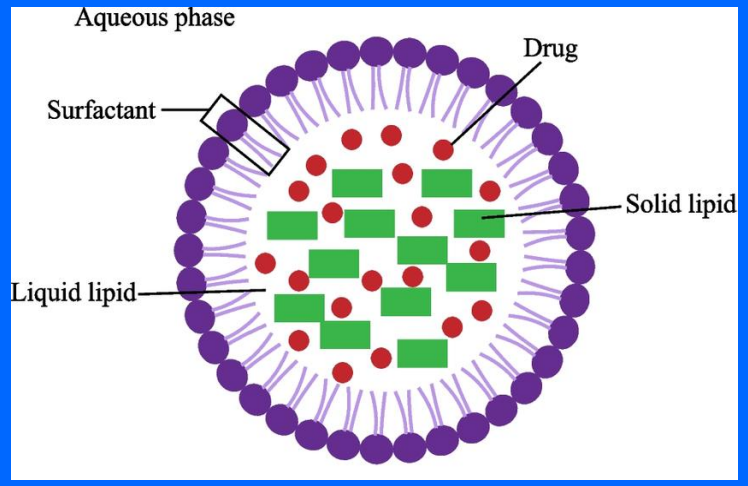


Fig. 1: Structure of Nanostructured Lipid Carrier

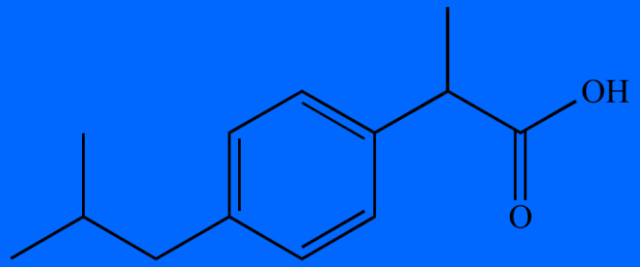


Fig. 2: Chemical Structure of Ibuprofen

Table 1: Potential Application, Advantages and Limitations of Nanostructured Lipid Carrier Loaded with Ibuprofen

Potential Application of IBU-NLC	Advantages of IBU-NLC	Limitations of IBU-NLC
Targeting Inflammation	Improved Drug Loading and Entrapment	Potential Cytotoxicity and Irritation
Overcoming Poor Skin Permeability	Controlled Drug Release	Surfactant Concentration
Oral Drug Delivery	Enhanced Stability	Drug Expulsion
Controlled Release	Biocompatibility and Biodegradability	Need for Careful Formulation and Processing
Increased Efficacy	Improved Skin Permeation	Challenges in Industrial Scale-Up
Sustained Release	Protection of Chemically Labile Compounds	Low Drug Loading for Some Drugs

Soni S, et al. Nanostructured Lipid Carrier: Beneficial Role in Oral Drug Delivery System. *BioNanoSci.* 2024; 14, 3988–4005.
Khan S, et al. An Overview of Nanostructured Lipid Carriers and its Application in Drug Delivery through Different Routes. *Adv Pharm Bull*. 2023; 13(3):446-460.

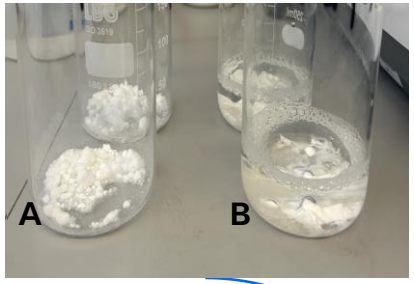
Materials & Methods (1)

Table 2: Formulation Design of Nanostructured Lipid Carrier Loaded with Ibuprofen 1% (NLC-IBU_1%)

Ingredients	Quantity (g)	Role / Function in Formulation
Ibuprofen, 98.5%	0.5	API; lipid phase
Precirol® ATO 5	2.0	lipid core in NLCs enhances hydrophobic drug entrapment and enables sustained-release delivery
Miglyol® 812 N	2.5	drug carrier and vehicle, particularly for lipophilic APIs, penetration enhancer and emollient; lipid phase
Polysorbate 80	2.0	surfactant, emulsifier, and solubilizer; aqueous phase
Poloxamer 407	1.0	surfactant and solubilizing agent; aqueous phase
Distilled Water	42.0	aqueous phase

✓ Method of preparation of NLC-IBU_1%

1. Preparation of Lipid Phase (A) and Aqueous Phase (B)



2. Dissolving of Aqueous Phase / Melting of Lipid Phase on Water Bath (75°C) for 20 mins

3. Micronization with ULTRA Turrax to obtain microemulsion (3 mins / 8000 rpm)

4. Sonication with SONICS VibraCell to obtain nanoemulsion (15 mins / 70% ampl.)

5. Cooling the nanoemulsion for 15 mins in ice-cubes

Materials & Methods (2)

✓ **Methods for physicochemical characterization of NLC loaded with Ibuprofen 1%**

Malvern ZetaSizer-DLS (Dynamic Light Scattering)

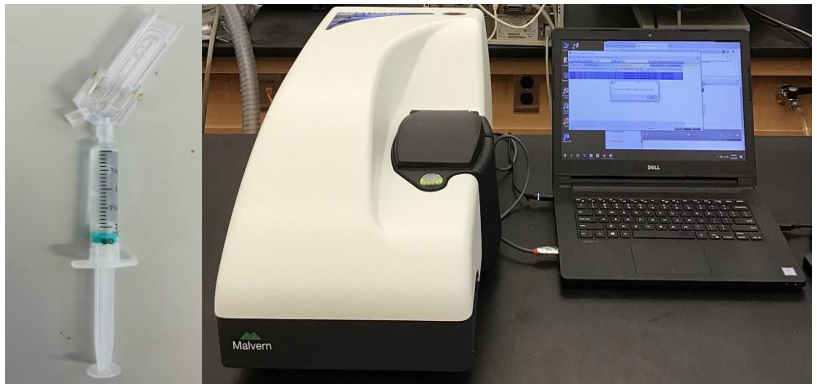
- ✓ Method: DTS1070
- ✓ Material: liposomes
- ✓ Dispersant: water
- ✓ Temperature: 25.0°C
- ✓ Equilibration time: 120 s

Transmission Electron Microscope (TEM)

- ✓ Samples (10 µL) were placed on Formvar/carbon-coated nickel grids and left for 2 min.
- ✓ Excess liquid was blotted, and grids were stained with 1% uranyl acetate for 10 s.
- ✓ After drying, samples were examined using a JEOL JEM-1400 TEM at 120 kV, and images were captured with an Orius 1100W CCD camera.

HPLC-DAD (Dionex UltiMate 3000)

- ✓ Column: BDS Hypersil C18 (150 x 4.6 mm)
- ✓ Mobile phase: Water (pH=3.0):ACN=40%:60%
- ✓ Flow rate: 1 mL/min
- ✓ Wavelength: 265 nm (Ibuprofen)
- ✓ Temperature: 29.0°C



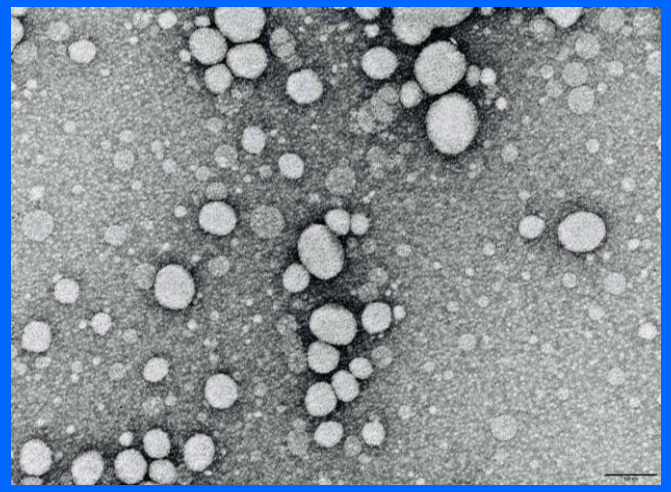
Results & Discussion (1)

Table 3: Summary results obtained on the day of production and two weeks later for the formulation, for the following parameters: ZP, particle size and PDI

Batch / Parameters	Zeta Potential (mV)	Size (nm)	Polydispersity index (PDI)
Blank-NLC (manuf. date)	-32.5	103.0	0.132
Blank-NLC (2 weeks later)	-30.68	106.06	0.11
NLC-IBU_1% (manuf. date)	-20.56	93.15	0.135
NLC-IBU_1% (2 weeks later)	-18.89	100.26	0.198

- ✓ **ZP: Stable if > +30 mV or < –30 mV**
  → **–18 to –33 mV = Stable**
- ✓ **Size: Nanoparticles = 1–100 nm**
  → **93–106 nm = Nano-range**
- ✓ **PDI: 0 = uniform, 1 = broad**
  → **0.1–0.2 = Monodisperse**

A



B

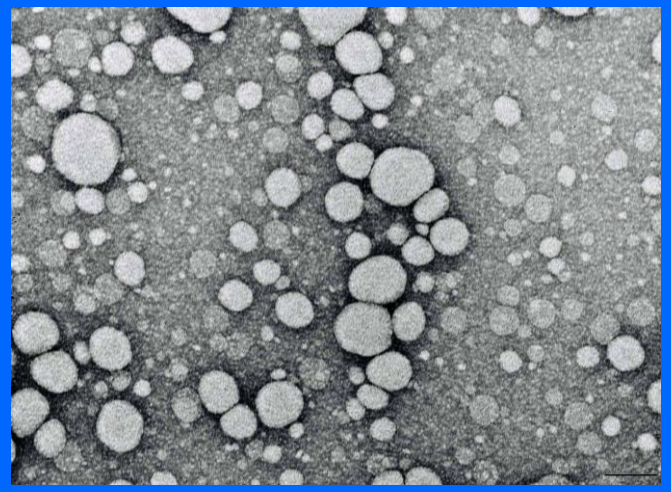


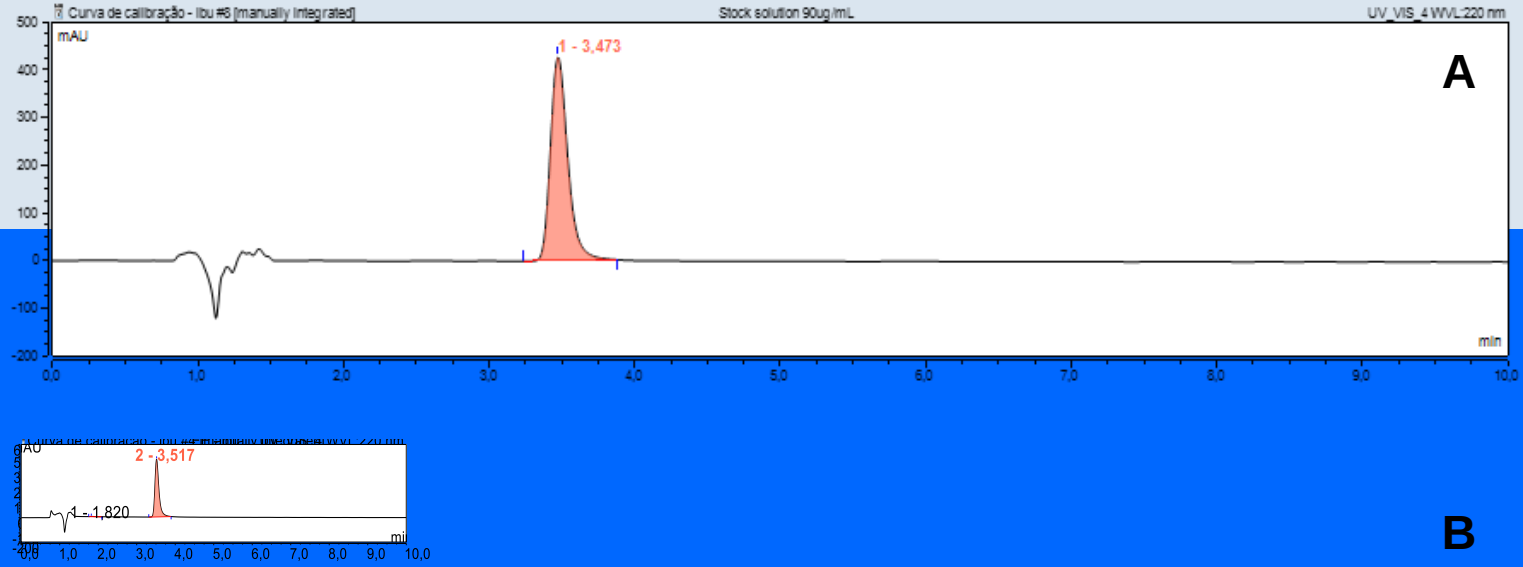
Fig. 3: TEM micrographs of spherical and uniform morphology of: A) Blank-NLC, and B) NLC-IBU_1%

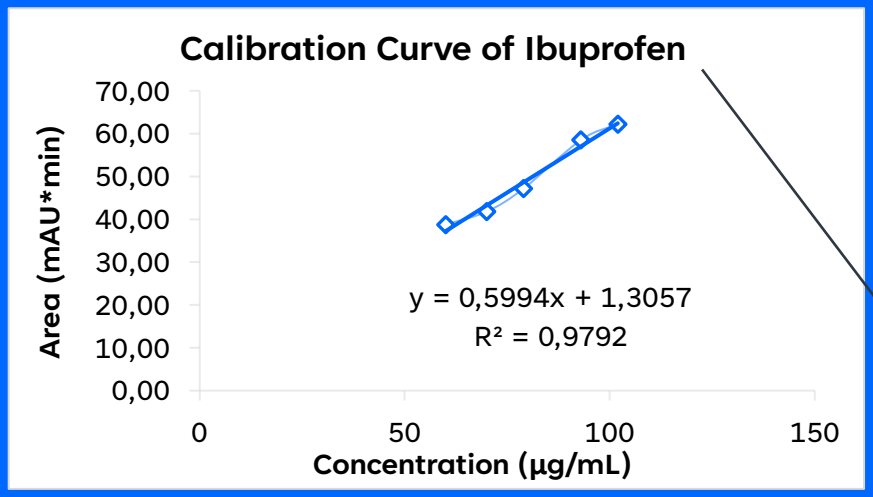
The NLC-IBU showed stable surface charge, nanoscale size, and uniform distribution, confirming a well-defined and monodisperse formulation.

Results & Discussion (2)

❑ Development of the HPLC Method for Identification and Quantification of Ibuprofen in NLC Formulation

- ✓ Apparatus: **Dionex UltiMate 3000**
- ✓ Detector: **DAD**
- ✓ Column: **BDS Hypersil C18 (150 x 4.6 mm)**
- ✓ Mobile phase: **Water (pH=3.0) : ACN = 40% : 60%**
- ✓ Flow rate: **1 mL/min**
- ✓ Wavelength: **265 nm (Ibuprofen)**
- ✓ Temperature: **29.0°C**





Encapsulation Efficiency (EE%) of Ibuprofen = 12%

Fig. 4: Chromatograms obtained from: A) a Standard Solution of Ibuprofen (90 µg/mL), and B) an Encapsulation Efficacy (EE%) of NLC-IBU_1%

Fig. 5: HPLC Assay of Ibuprofen – Calibration Curve and Encapsulation Efficiency

Conclusions

- ✓ NLC loaded with Ibuprofen 1% were made with the following characteristics: ZP=-20.56mV; Size=93.15nm and PDI=0.135.
- ✓ After two weeks, the formulation stored in the refrigerator (6°C) showed the following characteristics: ZP=-18.89mV; Size=100.26nm and PDI=0.198.
- ✓ The NLC-IBU_1% showed spherical and uniform morphology.
- ✓ The formulation is a stable monodispersion, free of agglomeration and with appropriate particle size for further applications.
- ✓ The encapsulation efficiency of Ibuprofen is 12%.

Future Perspectives

- ❖ Formulation optimization to improve the encapsulation efficiency of Ibuprofen...
- ❖ Differential Scanning Calorimetry (DSC)...
- ❖ Dissolution profile and release of Ibuprofen from the formulation (24-48h)...
- ❖ Long-term stability study (6 months)...
- ❖ Evaluation of therapeutic effect...

References ...

- Soni S, et al. Nanostructured Lipid Carrier: Beneficial Role in Oral Drug Delivery System. *BioNanoSci*. 2024; 14, 3988–4005.
- Khan S, et al. An Overview of Nanostructured Lipid Carriers and its Application in Drug Delivery through Different Routes. *Adv Pharm Bull*. 2023; 13(3): 446-460.
- Sütő B, et al. Development of ibuprofen-loaded nanostructured lipid carrier-based gels: characterization and investigation of *in vitro* and *in vivo* penetration through the skin. *Int J Nanomedicine*. 2016; 30(11): 1201-12.

Thank you for your attention!

Mihail J. Aleksandrov, MPharm.

/ Specialist in Pharmaceutical Technology /

Production Manager at AURA PHARM LLC, 1430 Kavadarci, R. N. Macedonia
PhD Student at Faculty of Medical Sciences, Goce Delcev University, 2000 Stip, R. N. Macedonia

mihail.aleksandrov@aura-pharm.com
mihail.311155@student.ugd.edu.mk

AURA PHARM

УНИВЕРЗИТЕТ
ГОЦЕ ДЕЛЧЕВ
ФАКУЛТЕТ ЗА
МЕДИЦИНСКИ НАУКИ