Prof. Farid CHEMAT

GREEN Extraction Team, UMR408 INRA – Université d'Avignon

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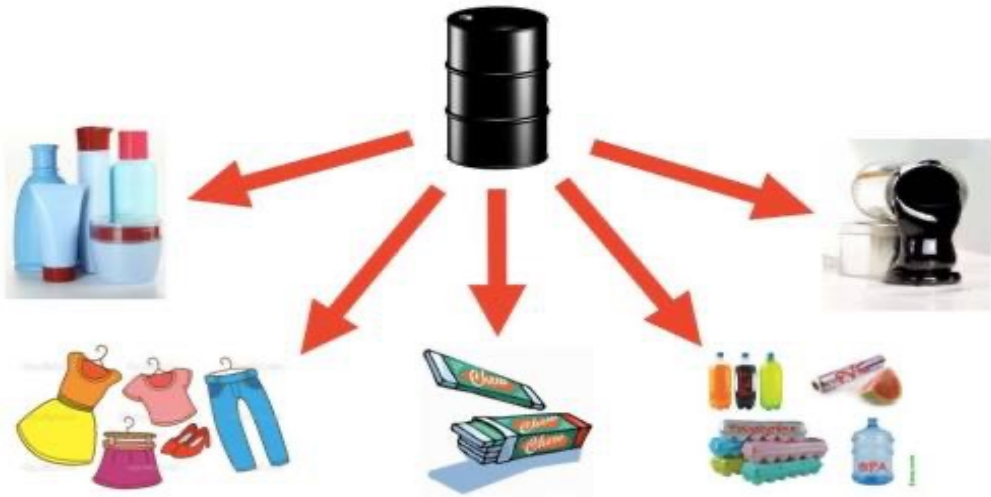
Vers une chimie durable

« sans pétrole »

grâce à l'Eco Extraction du Végétal

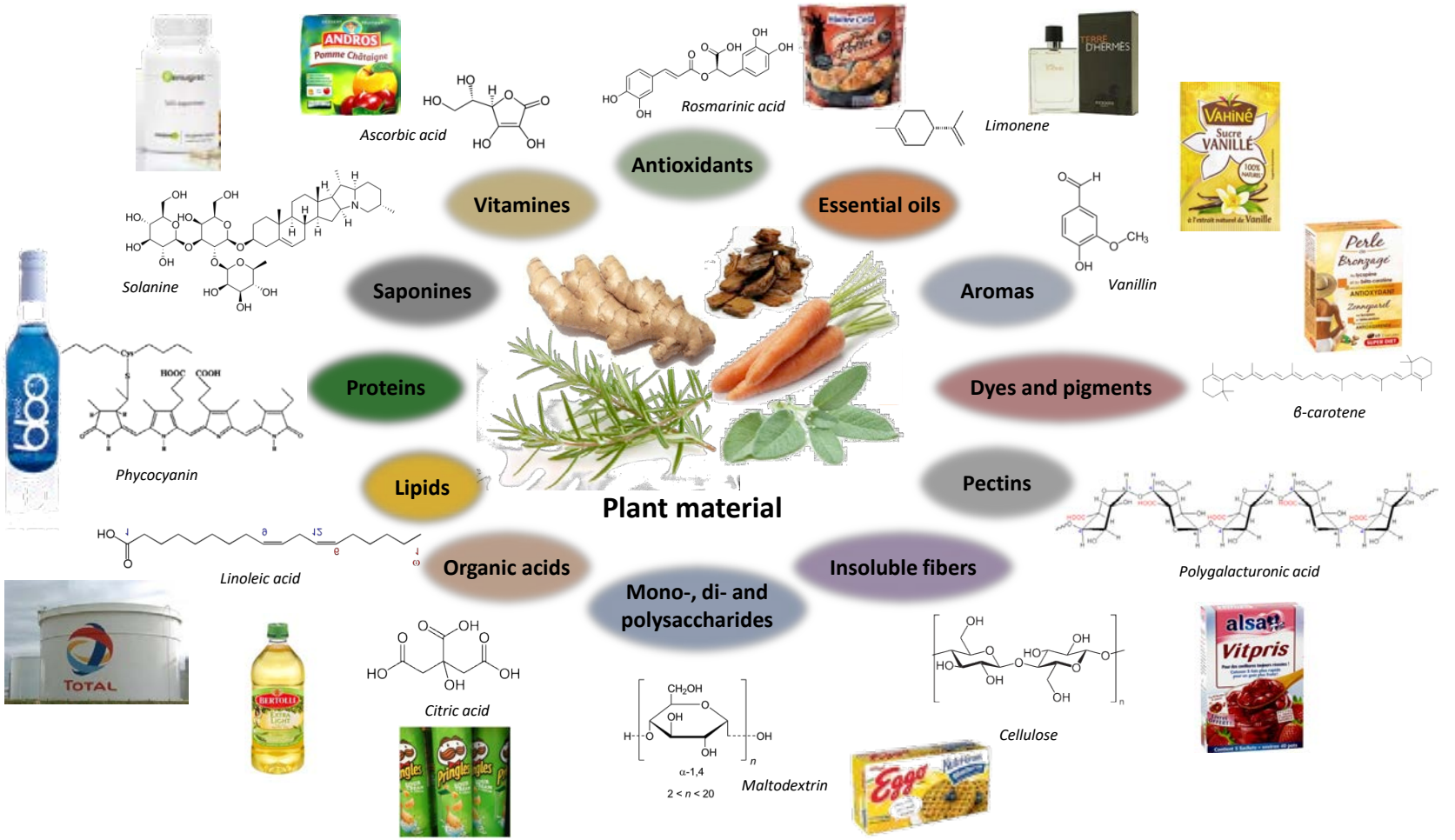
Petroleum products, ingredients and solvents

Food products and ingredients – Perfumes – Cosmetic –
Nutraceutics - Pharmaceutics



Mardi 25 mai 2021

Vers une chimie verte 2.0 - sans pétrole - grâce aux bio-ressources



EXTRACTION: WHAT ELSE?

Pressing
Hydrodistillation
Maceration
Decoction
Percolation
Leaching
Infusion
Digestion

Raw material

PROCESS

EXTRACTION

SOLVENT

Water
Ethanol
Acetone
Hexane
Dichloromethane
....

Waste

SEPARATION

EXTRACT

Essential oil

Vegetable oil

Concentrate juice

antioxidant

Color

Proteins

oleoresin

PURIFICATION

Compound

Food Ingredients and Products

Synthons

Bio Fuels

Nutraceutics

Cosmetics

Pharmaceutics

Extraction in Food, Pharma and Cosmetic Industry Problems Analysis

Processing time : hours or days

Energy cost

Processing by batch

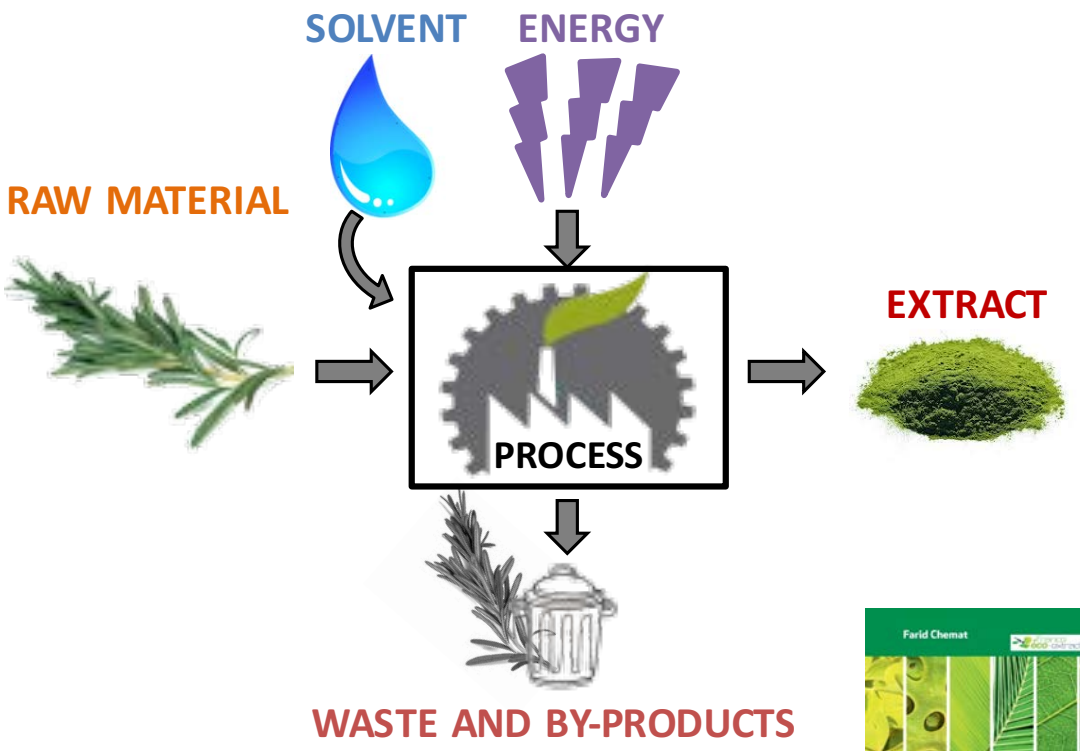
Problems of degradation

Reduction of water used

Use of « biobased » solvents

Reduction of waste: solid and liquid

Need for Innovation



GREEN or Eco - Extraction

Ecologic

Competitivity

Economic

Int. J. Mol. Sci. **2012**, *13*, 8615-8627; doi:10.3390/ijms13078615

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Review

Green Extraction of Natural Products: Concept and Principles

Farid Chemat [1,*], Maryline Abert Vian [1] and Giancarlo Cravotto [2]

Green Chemistry

ROYAL SOCIETY OF CHEMISTRY

TUTORIAL REVIEW

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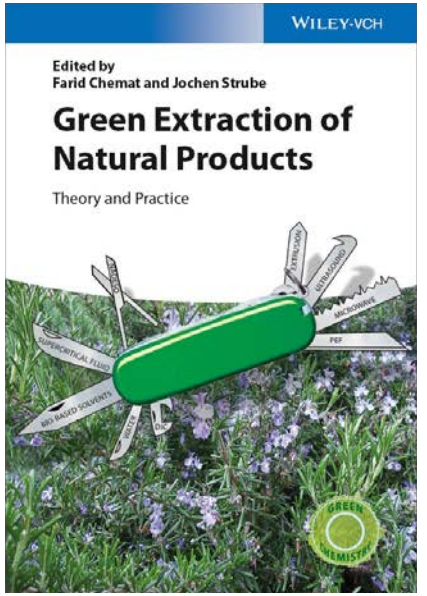
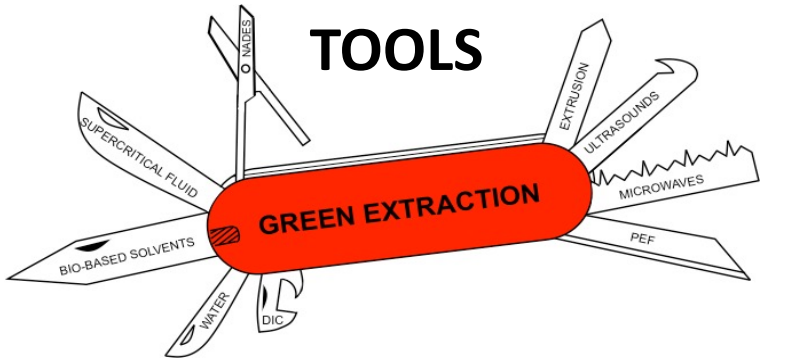
Cite this: *Green Chem.*, 2020, **22**, 2325

A review of sustainable and intensified techniques for extraction of food and natural products

Farid Chemat, *[a] Maryline Abert Vian,[a] Anne-Sylvie Fabiano-Tixier,[a] Marinela Nutrizio,[b] Anet Režek Jambrak,[b] Paulo E. S. Munekata,[c] Jose M. Lorenzo,[c] Francisco J. Barba,[d] Arianna Binello[e] and Giancarlo Cravotto[e]





Alternative Solvents

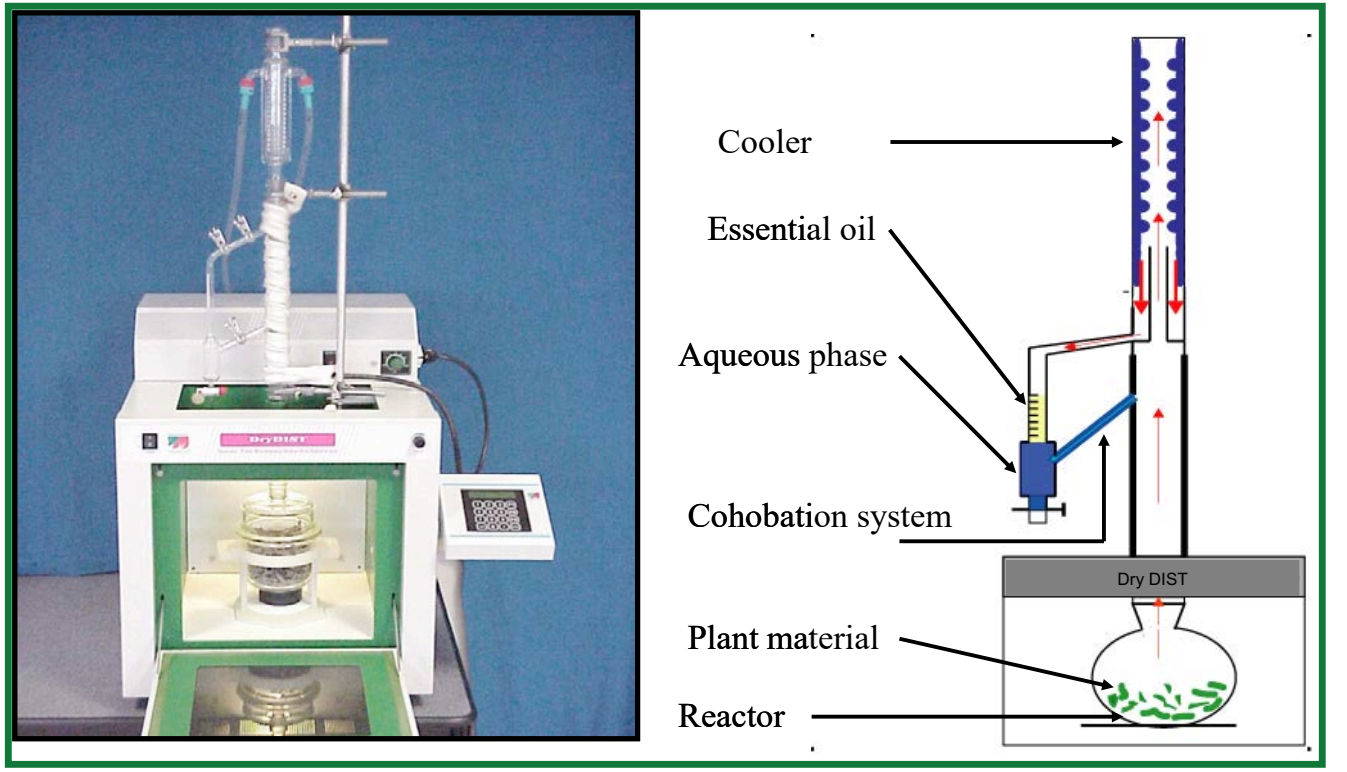
- Solvent Free
- Water (normal, subcritical, emulsions)
- CO_2, HFC, other gaz
- Vegetable oils
- Terpenes (limonene..)
- Byproducts (glycérol…)
- Ionic liquids

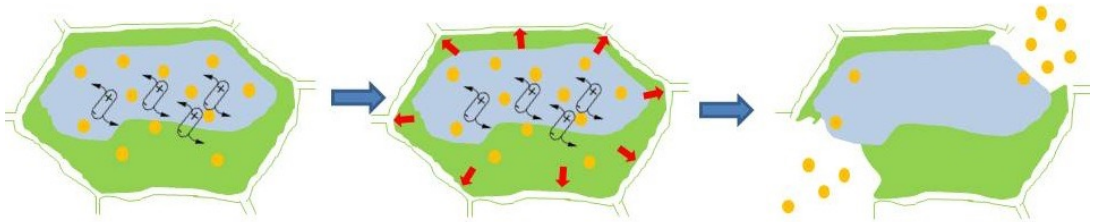
Innovative techniques

- Turbo-extraction
- Ultrasound assisted extraction (UAE)
- Accelerated solvent extraction (ASE)
- Microwave assisted extraction (MAE)
- Pulse electric field (PEF)
- Instantaneous decompression (DIC)
- Extrusion, induction…

MW-EXTRACTION
A Mature Technology

Dry Dist: microwave dry Distillation
Patents EP et USP 2004 by Chemat & Visinoni





Rotation of cell in-situ water under microwave irradiation

Rapid increase of temperature and pressure inside the cell

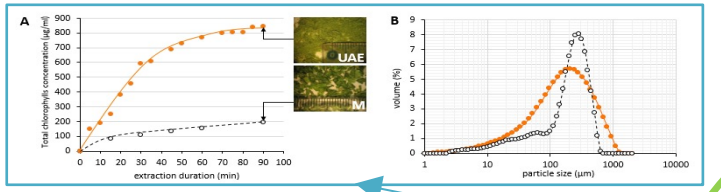
Cell break down and release of targeted molecules

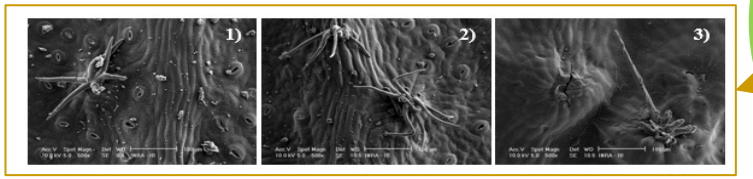
Dry Dist: microwave dry Distillation

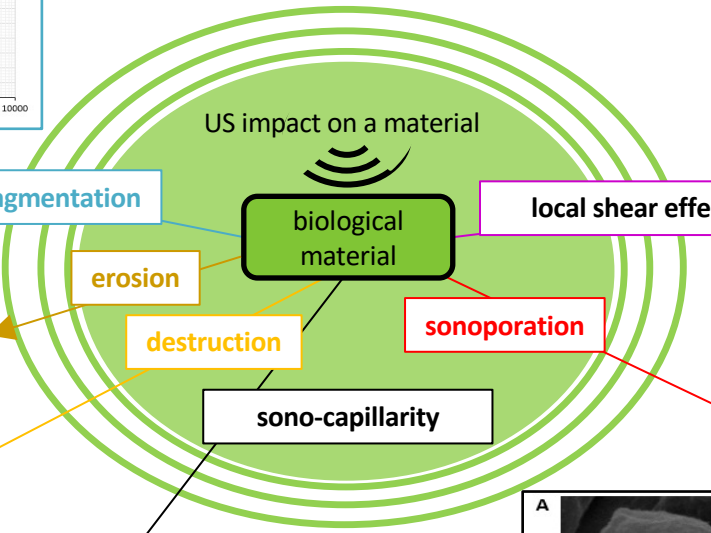
MW

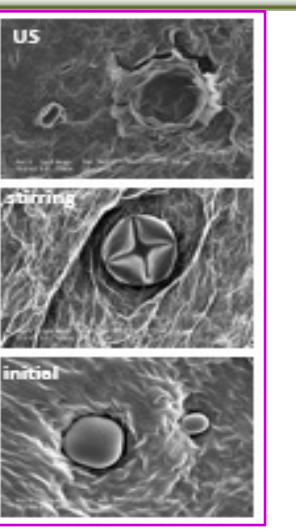
SONO-EXTRACTION
Water as Solvent

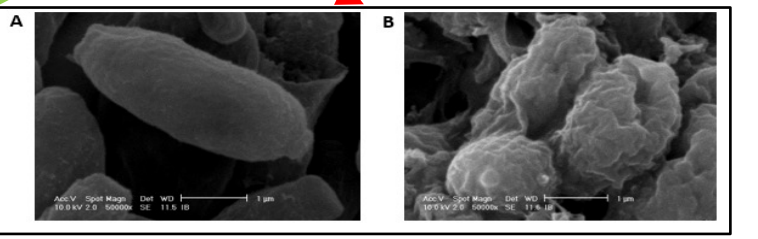
Towards understanding ultrasound impacts on vegetal tissues

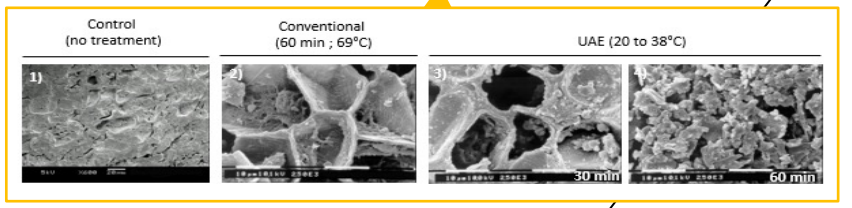


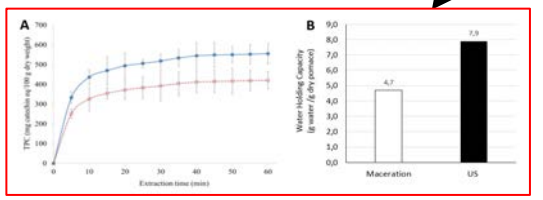










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journal homepage: www.elsevier.com/locate/ultson

Review

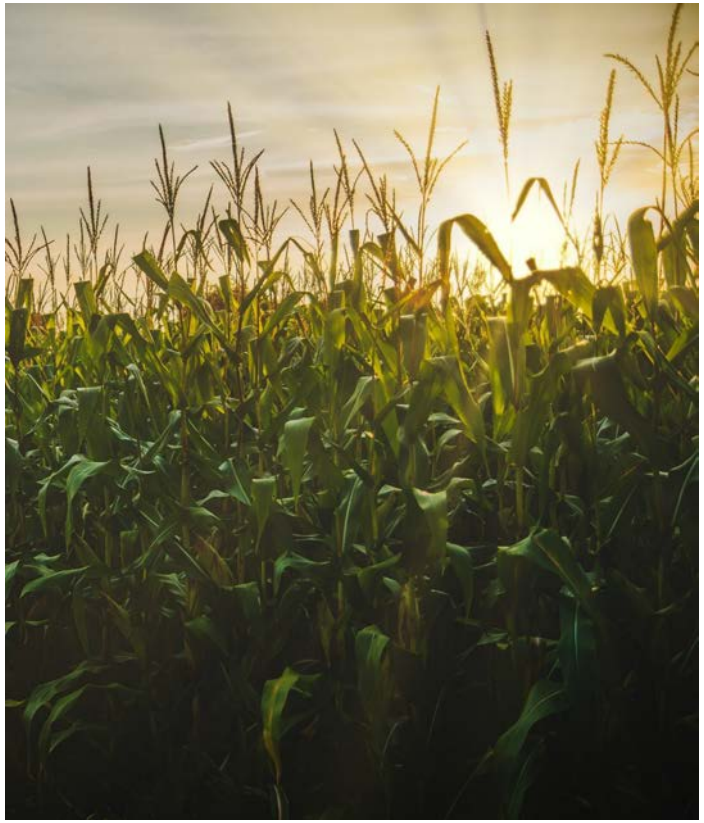
Ultrasound assisted extraction of food and natural products. Mechanisms, techniques, combinations, protocols and applications. A review

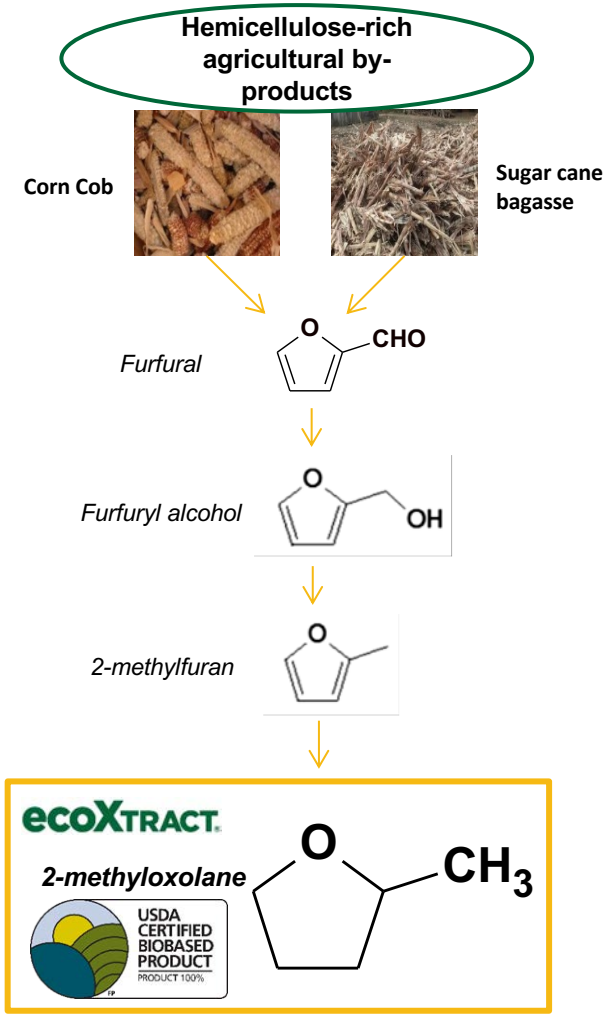
Farid Chemat *, Natacha Rombaut, Anne-Gaëlle Sicaire, Alice Meullemiestre, Anne-Sylvie Fabiano-Tixier, Maryline Abert-Vian

Université d'Avignon et des Pays de Vaucluse, INRA, UMR408, GREEN Team Extraction, F-84000 Avignon, France

Bio- based Solvents
Towards « hexane – free »

EcoXtract® is derived from hemicellulose, found in many agricultural by-products, in large quantities and does not compete with food supply





A safe solution for consumers, for workers and for the environment

1. Safe for consumers

- Toxicological profile compatible with the use for food and feed
- **No CMR effects, no endocrine disruption or neurotoxicity**
- 17x safer than hexane by ingestion (pharma assessment)

2. Safe for workers and operations

- **60x safer by inhalation** compared to hexane
- Unlike hexane, **no medical follow-up is required for workers**
- Odor detection allows operations to identify any leaks by nose

3. Safe for the environment

- **Harmless eco-toxicological profile** across aquatic environment
- **Biodegradable** substance
- **A low carbon footprint** : -90% vs. standard petrochemical solvent

Regulatory status in different markets

Pharma

- **Already used for more than 10 years in pharma**
- Pharma-grade solvent is classified as « low toxicity solvent » (Class 3 list – ICH Q3C Guideline) for pharma, same classification as ethanol

Cosmetics

- EcoXtract® can be used for the production of **organic cosmetic ingredients** (COSMOS approval)

Food

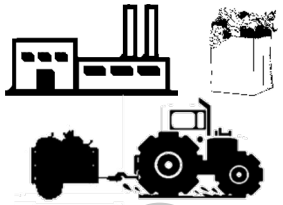
- **Europe** : food approval expected in 2022 (**currently under EFSA review**). Organic recognition targeted
- **Canada** : approval expected in 2022
- **US**: approval expected in 2023

Feed

- **Europe** : Authorized in feed
- **China :** Authorized in feed
- **US/Canada** : approval expected in 2022

Nouveau Concept
Usines Cellulaires

ENTOMOCONVERSION



1

2

Nutritional upscaling

3

4

Waste substrates
Bioconversion
High-value products
Various applications

Fruit and vegetable wastes are crushed and conditioned to at least 70% moisture.

Insect bioconversion

Larvae and frass are the outputs emerging from the bioconversion process.

1 ton of waste F&V substrate

Converted by BSFL

14 to 21 days

Yields **125 kg** of fresh BSFL and **250 kg** of frass

1 Ton of F&V waste

-

Moisture content – 739
Protein – 39
Lipids – 28
Total carbohydrates – 175

-

*All values in kilograms

Nutrition

Upcycling

40 kg of dry BSFL

-

Protein – 13
Lipids – 15
Total carbohydrates – 6
Chitin – 1

-

*All values in kilograms

Industrial applications of lipid, protein, chitin fractions and frass

Insect meal
Energy
Proteins & lipids
Animal nutrition

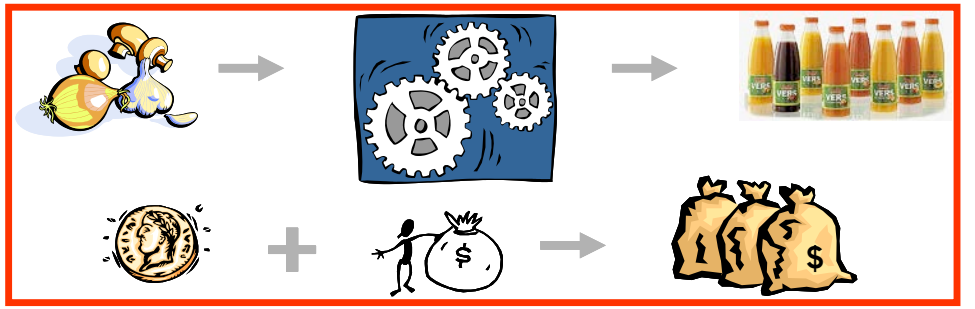
Vers une chimie durable « sans pétrole » grâce à l'Eco Extraction du Végétal

Education

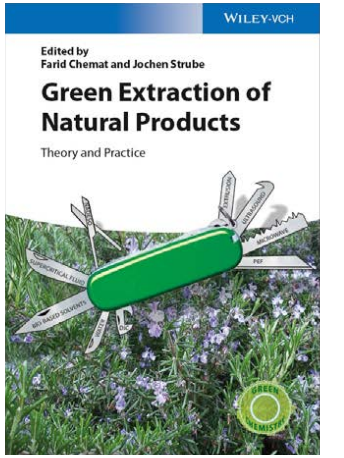
INNOVATION

ISO Standard and Label

Industrial Applications



R&D



GREEN Extraction Team – Avignon University

Overcoming technology limitations by creating devices for our research and education

Microwave Extraction Reactors

Lab reactors

NEOS-GR

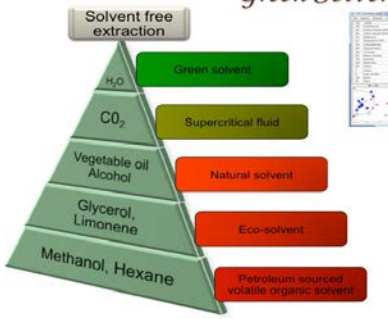
Pilot Plant

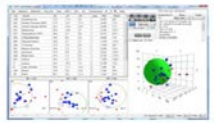
Ultrasound Extraction Reactors

Lab reactors
Hielscher UIP 1000 (20kHz, 1000W) 1 L or 40 L per h
REUS (25 kHz, 200 W, 3 L)

Pilot Plant
Hielscher (20kHz, 4000W) 1000 L per h
REUS (25 kHz, 800 W) 30 L

Green Solvents





Compressed Fluid as Green Solvents