Lipid based nano-reinforced polymers from a poultry byproduct: The spent hens

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Spent hen



Disposal of spent hens

http://plastic-pollution.org/ accessed on July 19, 2018

Introduction

- **Worldwide - 2.6 billion**
- **North America -150 million**
- **Canada - 32 million**
- **Spent hen ~1.8 kg**
- **16% lipid**

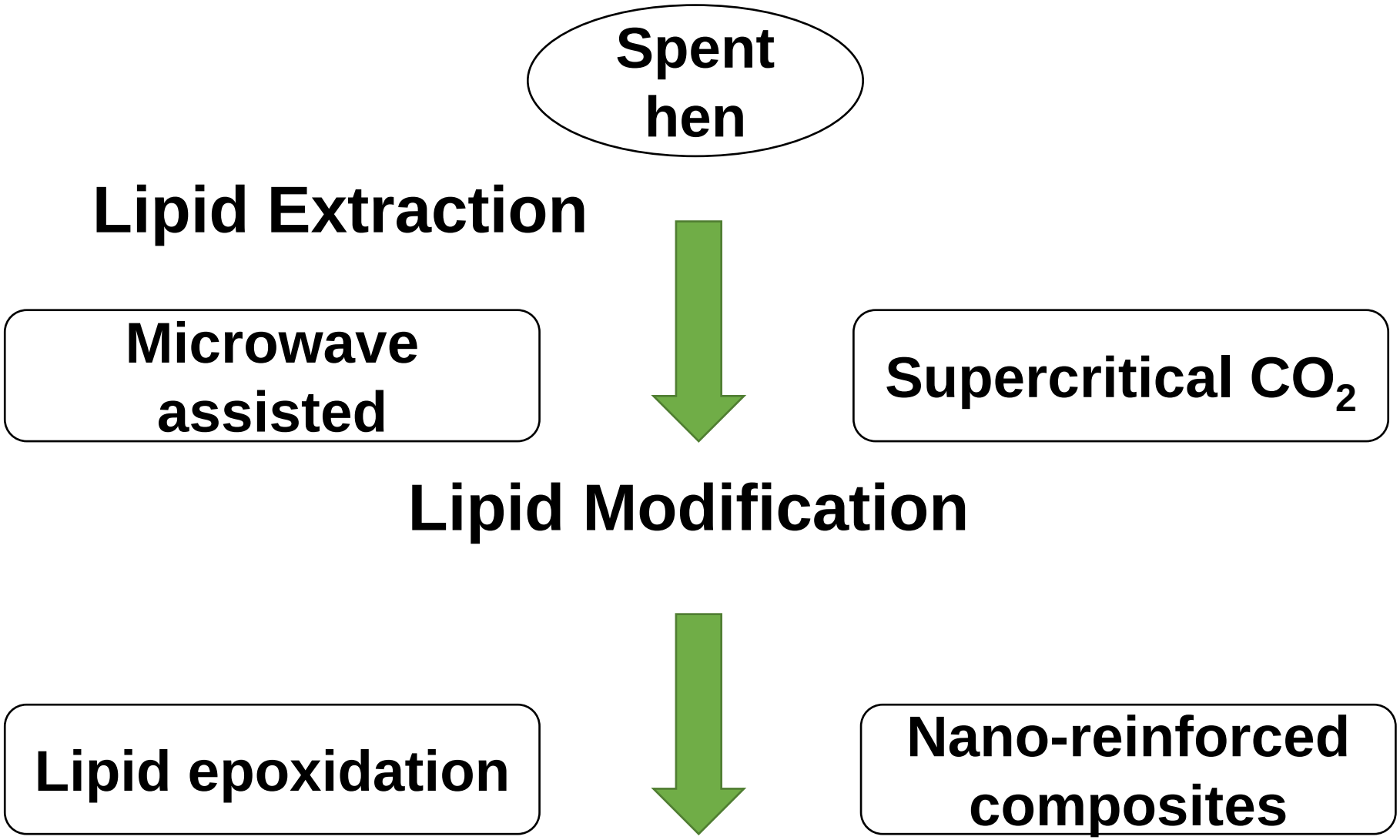
Kondaiah, N.; Panda, B., Processing and utilization of spent hens. *World's Poultry Science Journal* **2007,** *48* (3), 255-268

Objectives

- **Extraction of lipids from spent hen**

- **Modification of lipids for food packaging applications**

Experimental Design



Proximate analysis

- 60.1 ± 0.1% moisture
- 21.4 ± 0.1% protein
- 16.3 ± 0.2% lipid
- 2.2 ± 0.2% ash content.



Microwave extractor



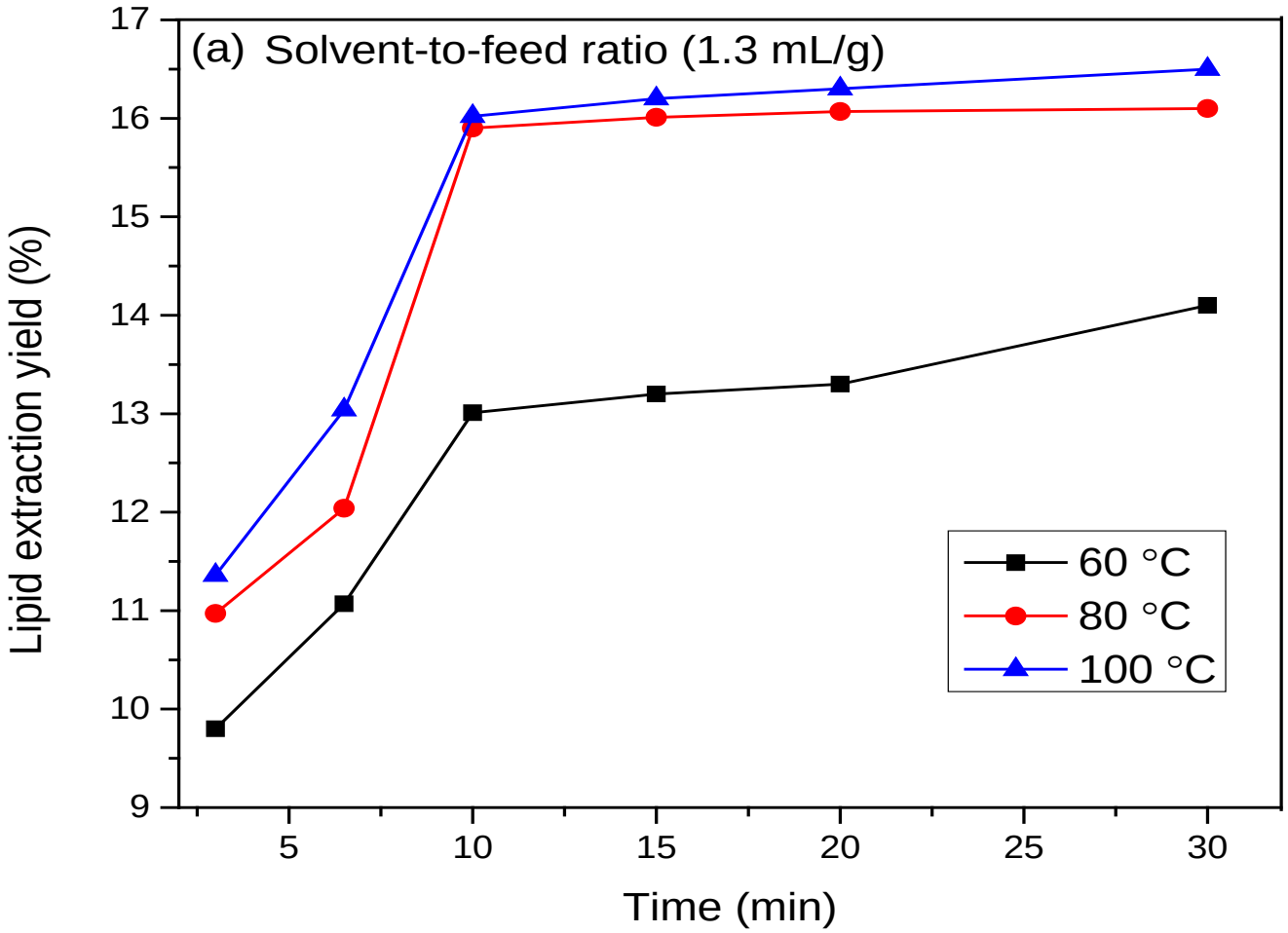
Ground spent hen



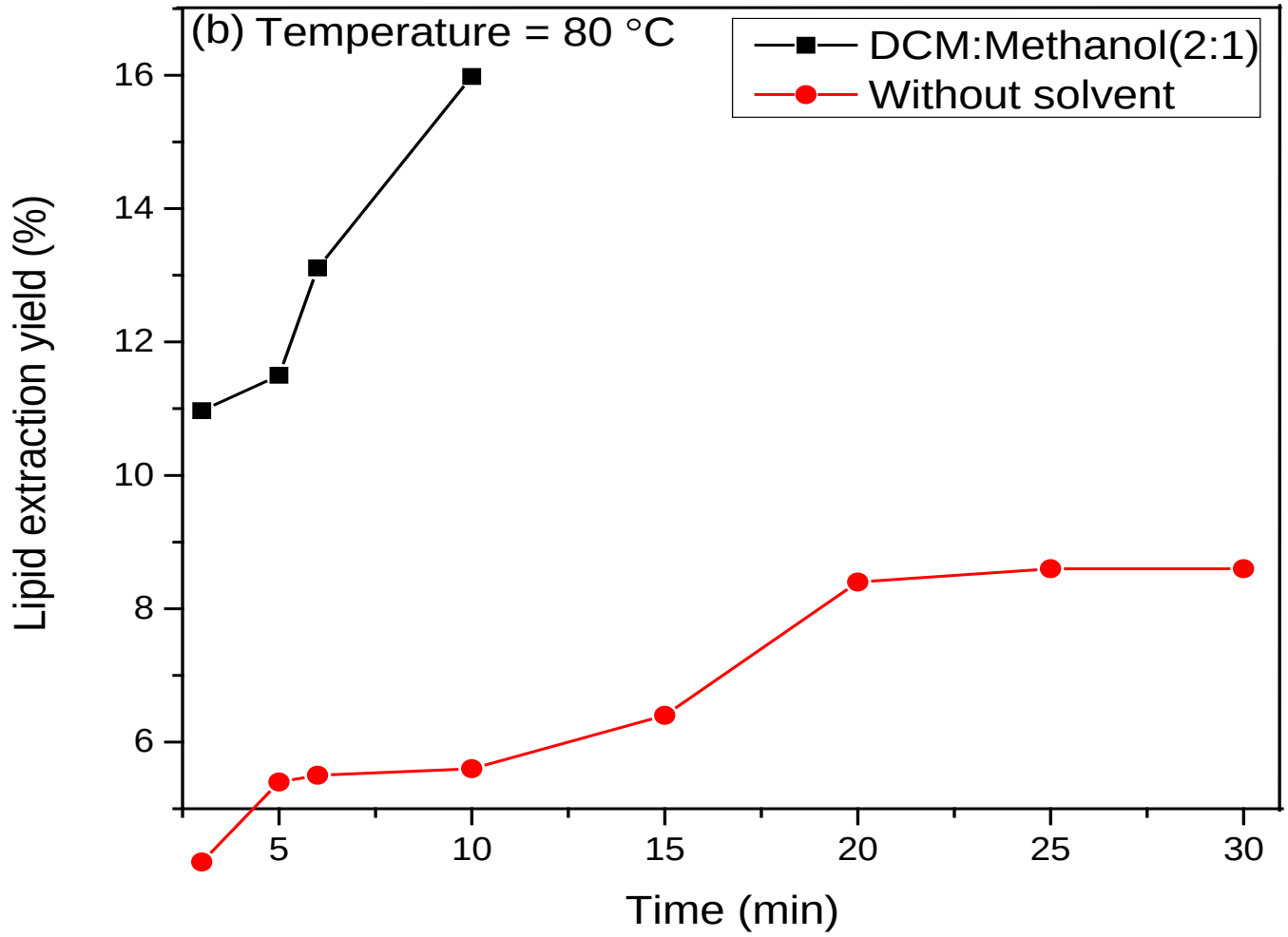
Extracted lipids

Graphical representation of Microwave assisted extraction

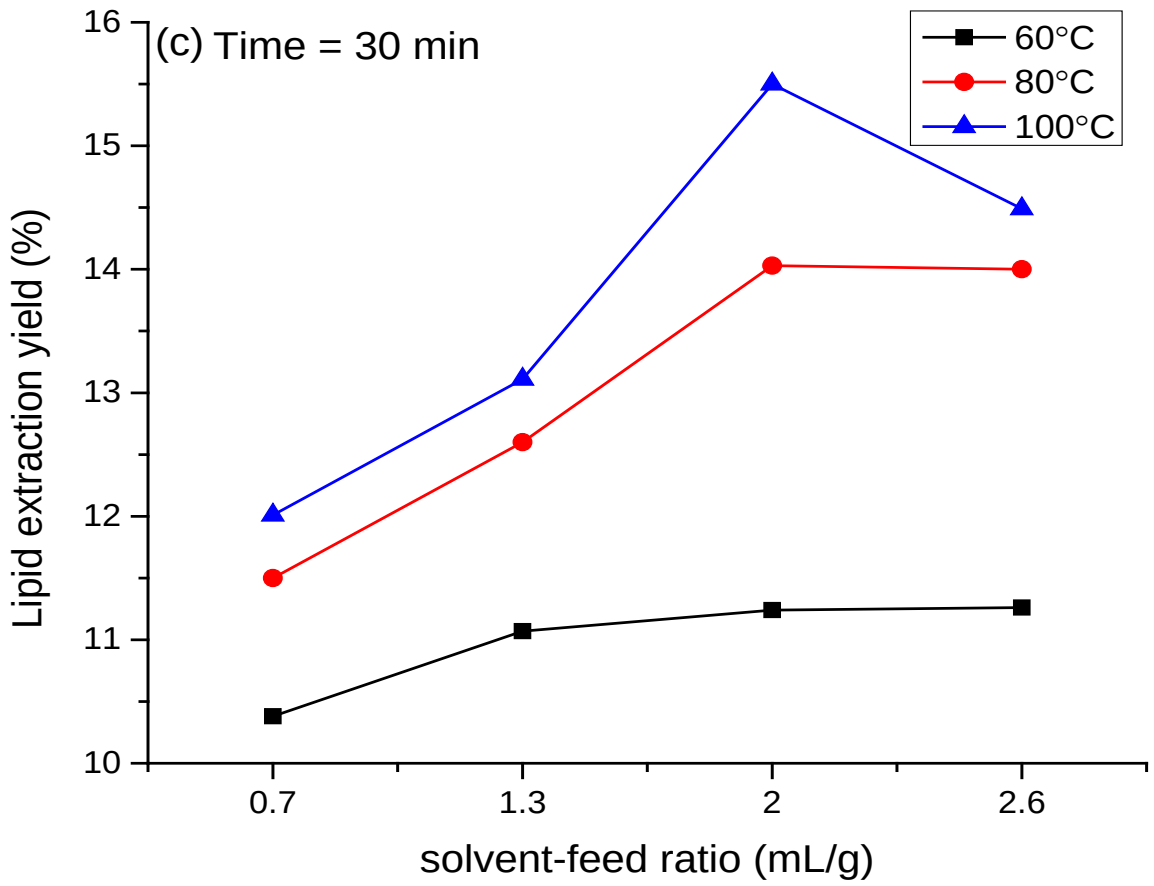
Temperature effect on lipid extraction yield



Effect of organic solvents addition on lipid extraction yield

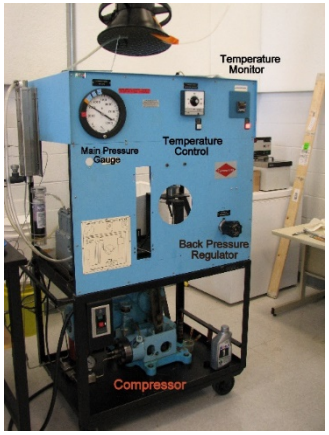


Influence of solvent-to-feed ratio on lipid yield

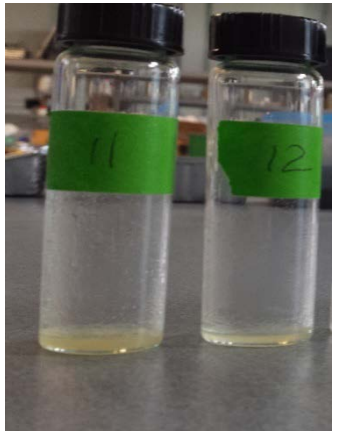


Microwave Assisted extraction

Temperature (°C)	Time (min)	Solvent-to-feed ratio (mL/g)	Yield (%)
80	6.5	1.3	12.7
60	10	1.3	13.0
80	6.5	1.3	11.1
60	6.5	2	11.3
60	6.5	0.7	10.4
100	3	1.3	11.4
80	6.5	1.3	11.2
80	**10**	**2**	**15.9**
60	3	1.3	11.0
100	6.5	0.7	12.0
100	6.5	2	14.0



SC-CO_2 Extractor



Extracted lipids

Epoxidized lipids



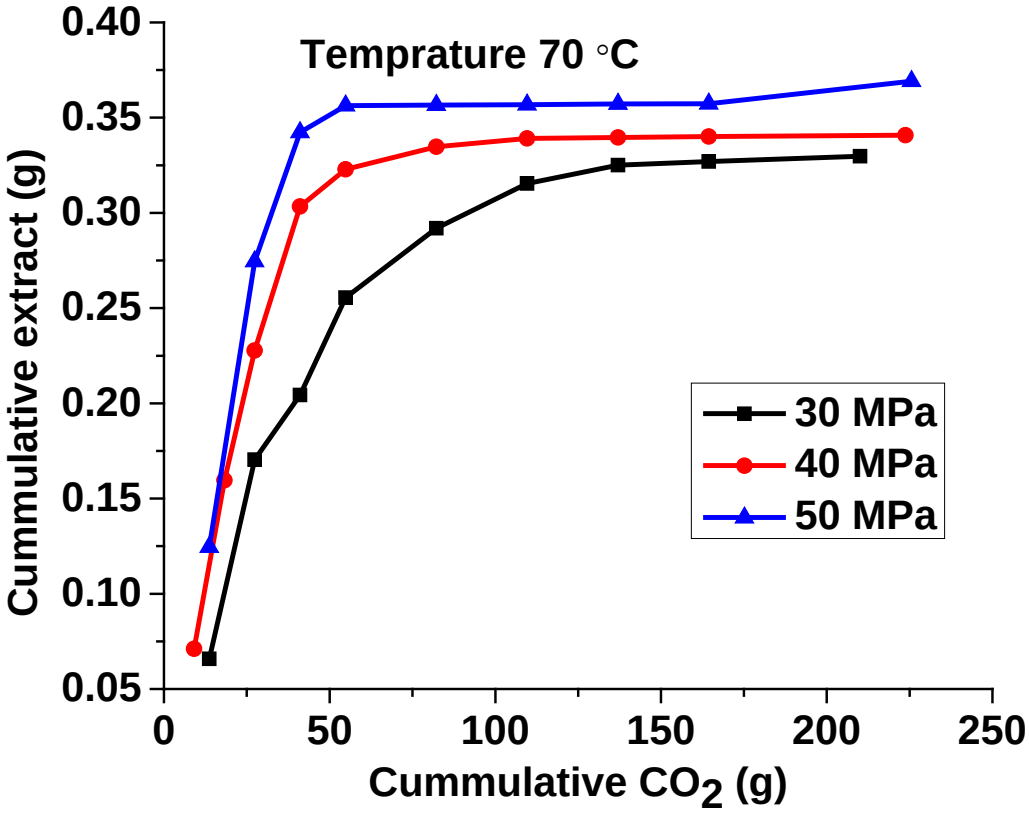
Ground spent hen

Graphical representation of Supercritical CO_2 Extraction

Experimental Conditions

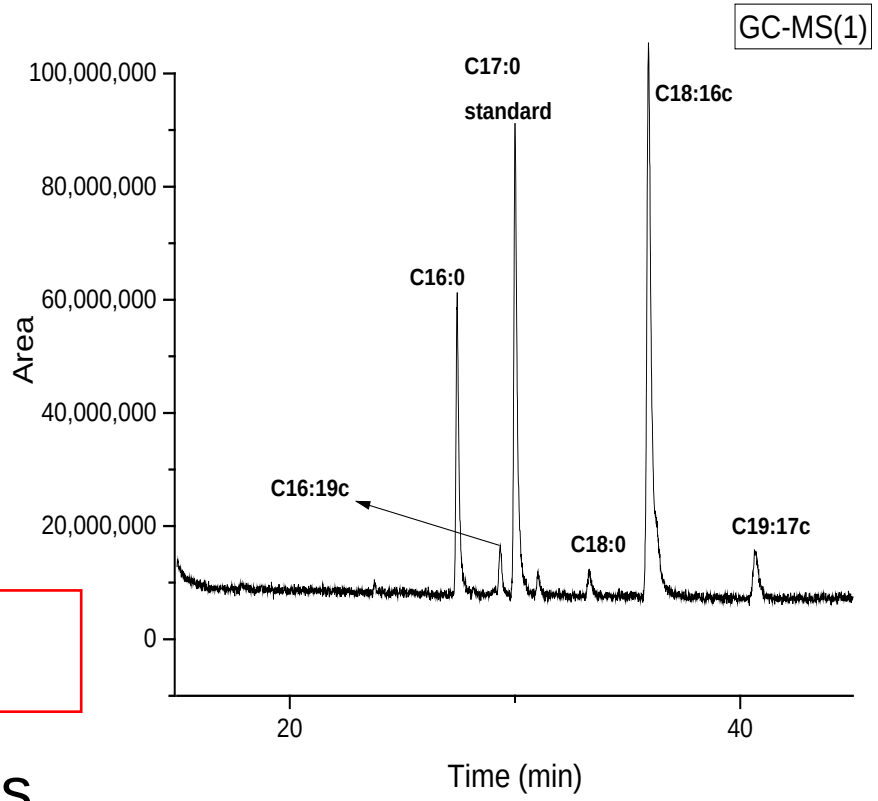
- Temperatures 40, 55, and 70 °C
- Pressures 30, 40, and 50 MPa
- CO_2 flow rate 1 L/min

SC-CO_2 extraction of lipids

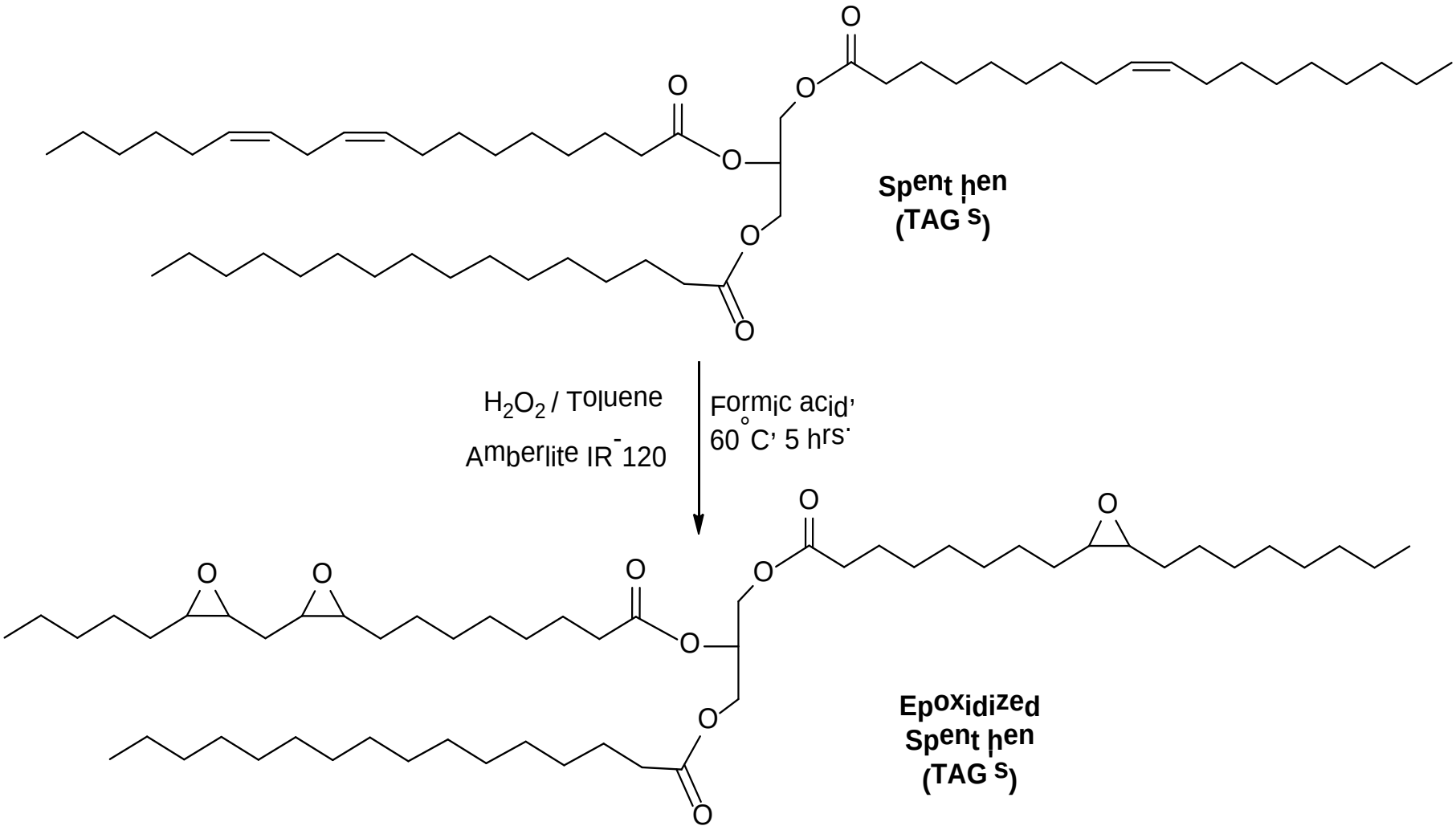


Fatty acid compositional analysis GC-MS and GC-FID

- Myristic (0.8-1.4±0.2%)
- Palmitic (19.5-24.8±2.5%)
- Palmitoleic (4.1-5.9±0.5%)
- Stearic (4.7-6.8±0.8%)
- **Oleic (52.1-59.9±2.7%)**
- Linoleic (5.6-15.9±5.2%) acids

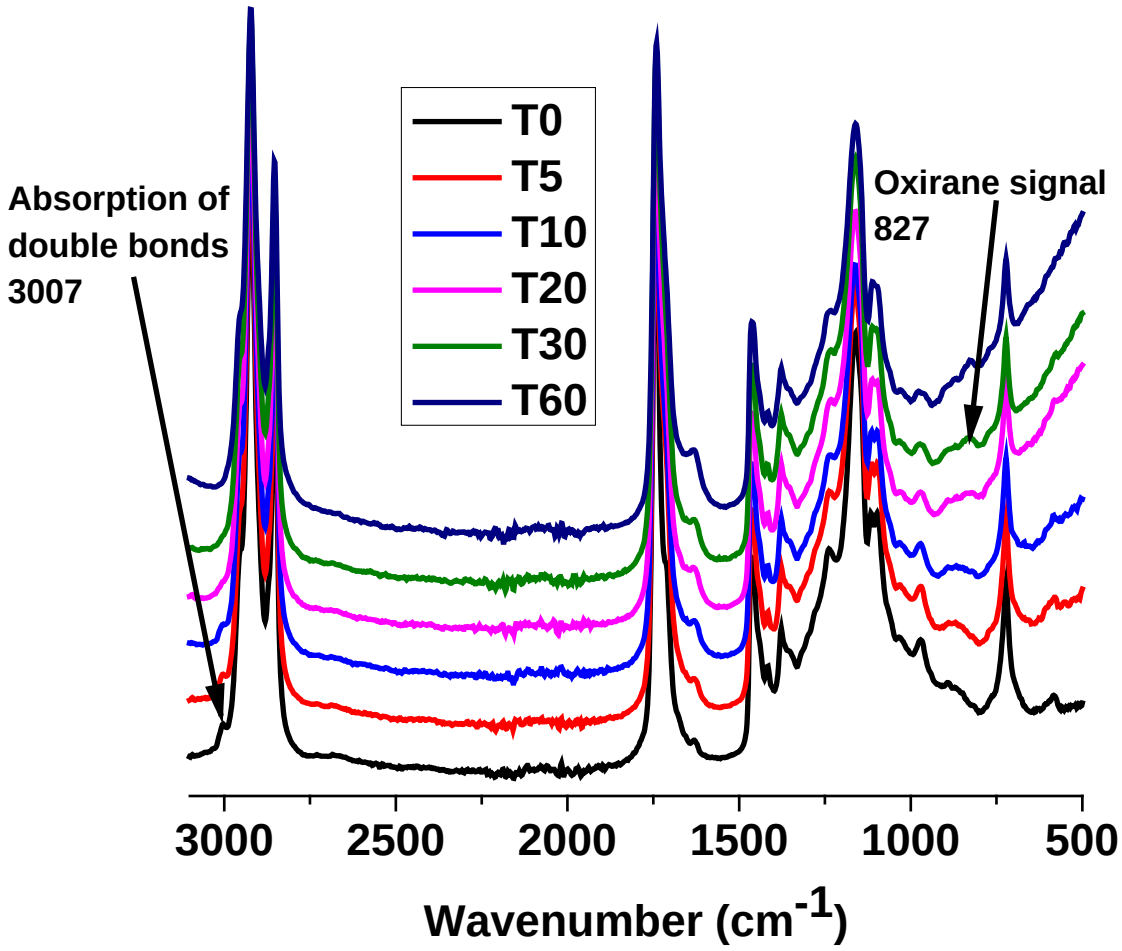


Epoxidation

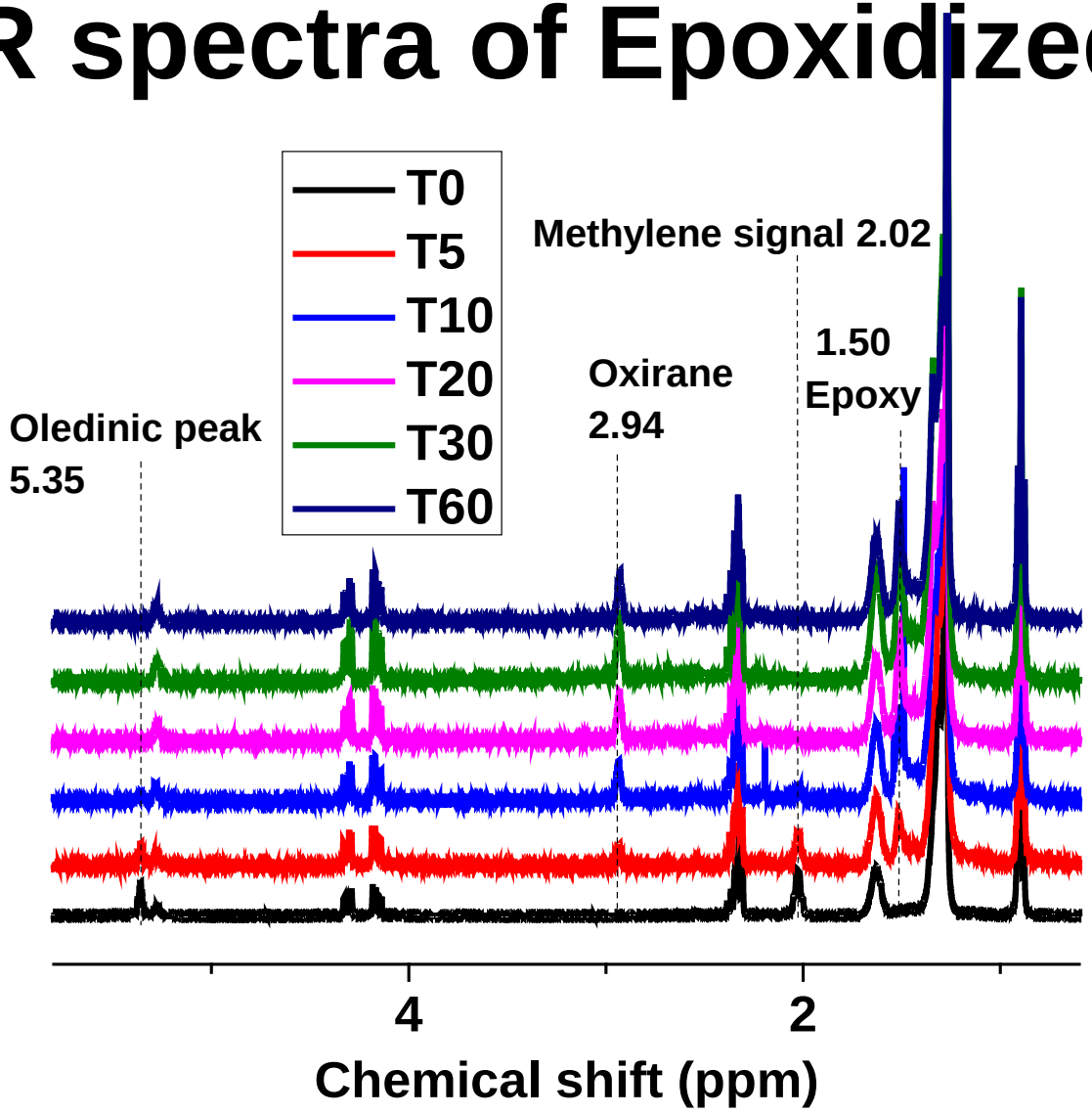


Schematic representation of epoxidized spent hen lipids

ATR-FTIR analysis of epoxidized Lipids



^{1}HNMR spectra of Epoxidized Lipids



Nano-reinforced composites Preparation







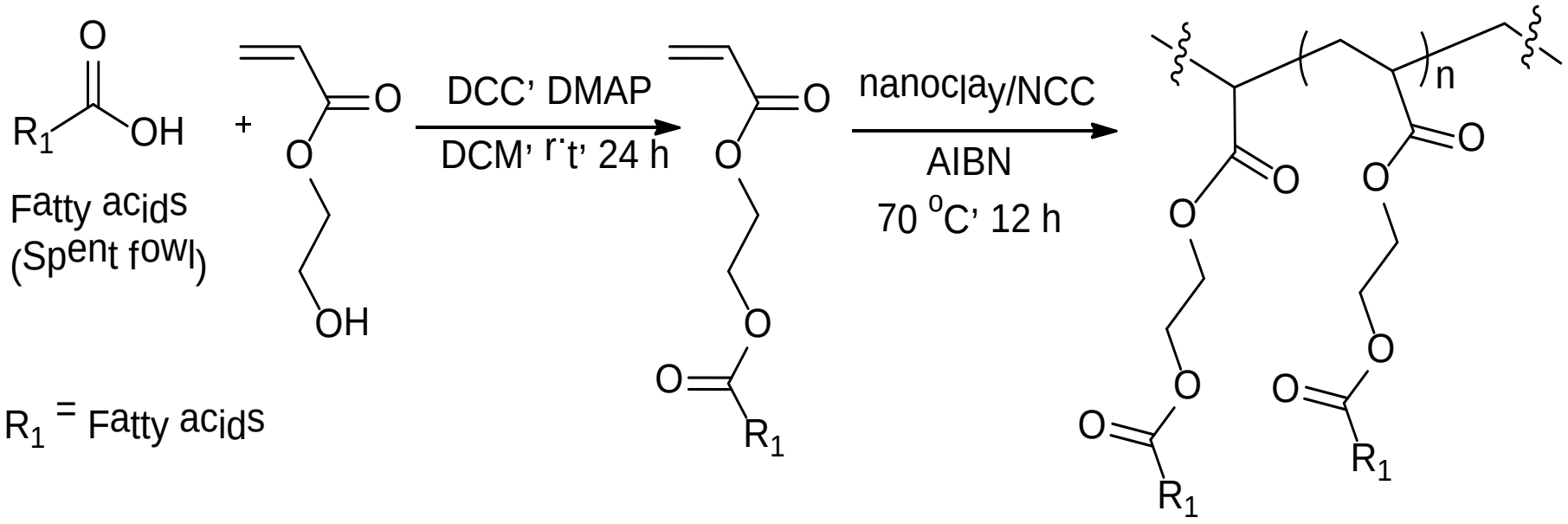
Composite formation

Extracted lipids



Prepared films

Nano-reinforced Biocomposite Preparation Scheme



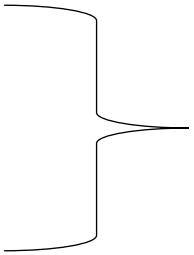
R_1 = Fatty acids

Optimization Conditions for Polymerization

Exp. No.	Temperature (°C)	Time (hour)	Conversion (%) using ^{1}HNMR	Molecular weight (M_w) using GPC
$P_{8\text{-}70}$	**70**	8	99	1.8781×10^5
$P_{12\text{-}70}$		12	100	1.4092×10^5
$P_{15\text{-}70}$		15	100	1.4231×10^5
$P_{24\text{-}70}$		**24**	**100**	**2.8582×10^5**
$P_{8\text{-}90}$		8	100	1.9722×10^5
$P_{12\text{-}90}$		12	100	7.7443×10^4
$P_{15\text{-}90}$	90	15	100	2.4407×10^5
$P_{24\text{-}90}$		24	100	1.0829×10^5
$P_{8\text{-}110}$		8	100	2.9859×10^4
$P_{12\text{-}110}$		12	100	2.3213×10^4
$P_{15\text{-}110}$	110	15	100	5.7803×10^4
$P_{24\text{-}110}$		24	100	4.2382×10^4

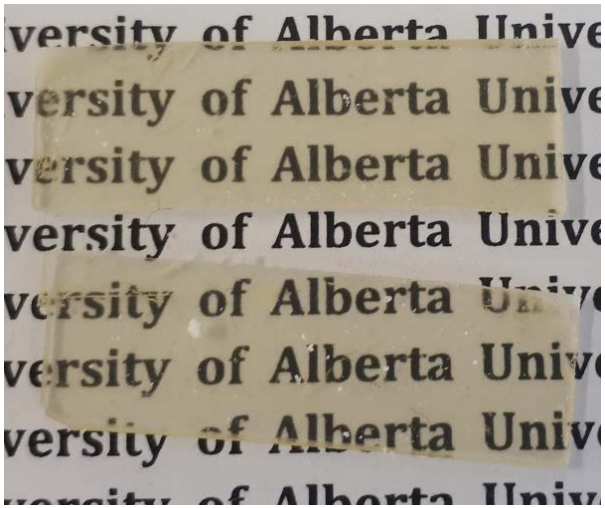
Addition of nanoparticles

- Nanoclay
- POSS
- Nano crystalline cellulose

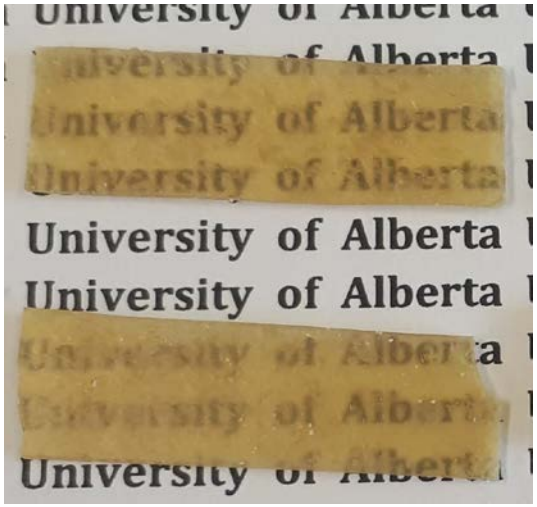


1, 3, 5, and 10%

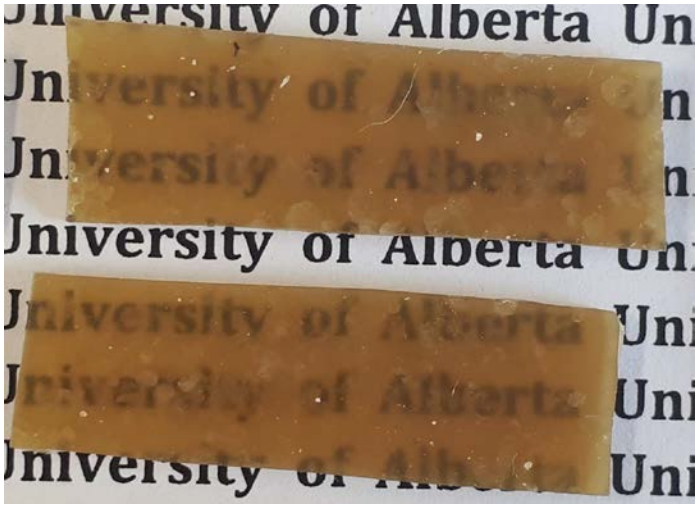
Prepared Films



3% nanoclay



5% nanoclay



10% nanoclay

Conclusions

- 98% lipid recovery obtained using 2 mL/g solvent-to-feed ratio for 10 min at 80 °C
- 94% of lipids were recovered at 50 MPa and 70 °C
- Solvent free extraction
- Solvent-free epoxidation
- Rapid epoxidation of lipids in less than 30 min
- Films prepared by addition of 3, 5, and 10% clay

Acknowledgements

- **Dr. Aman Ullah (Supervisor)**
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Thank you very much!



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