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The effect of cavitation in the optimal extraction of active ingredients from medicinal plants (Thymus vulgaris and Eucalyptus)

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ABSTRACT:
In this study, ultrasonic cavitation was used for cellular destruction and homogenization. The energy of the ultrasonic waves can cause severe compressive waves in the fluid environment; giving rise to its flow and the formation of micro-bubbles under proper conditions. The growth and combining of these micro-bubbles up to their maximum size and their final burst can result in a high amount of heat. Ultrasonic waves were used to extract the effective pharmaceutical agents of thyme and Eucalyptus The non-edible grade Thyme and Eucalyptus oils were evaluated by gas chromatography.

Keywords: Thymus vulgaris,Eucalyptus,Gas chromatography,Ultrasonic cavitation

INTRODUCTION:

To decline the size of particles, the large bulks should be crushed into smaller particles that require external forces. The decrease in the particle size often depends on the energy used for the particles, its application rate, and the energy supply method, the severe transient condition of the collapse in the cavitation-formed bubbles can be exploited to decrease the particles size up to nanometer scale. Some of the methods used for the synthesis of the nanoparticles are sonochemical methods, cavitation processes, and high-energy milling.In the sonochemical procedures and cavitation phenomenon, transient hot local regions are formed with high temperature and pressure gradient. Such a drastic and sudden variation in the temperature and pressure can contribute to the sonochemical destruction of the precursors and the formation of nanoparticles. This technique is indeed capable of large-scale production of materials for industrial purposes.[1-2]To understand the formation mechanism of the nanoparticles during the cavitation phenomenon, the hotspot theory can be used. This can explain the adiabatic bubble collapse theory as the result of hotspot presence. This theory proves that high temperatures (of the order of 5000 to 25000 K) are generated upon the bubbles bursting. As this collapse occurs in several microseconds (final adiabatic phase), a high cooling rate is also formed (more than 10^{11} K/s). this cooling hinders the organization and crystallization of the products. In the case of volatile precursors I

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which the reactions are dominantly in the gas phase, the obtained nanoparticles are amorphous. One of the explanations for nanostructures formation by cavitation process is that the fast kinetics does not allow for germination. Several germination centers are formed in each collapsing bubble whose growth will be limited due to the short collapse times.. in other words, if the precursors are non-volatile, the reaction will occur in a 200-nm loop of the collapsing bubble. At such conditions, the sonochemical reaction occurs within the liquid rather than the internal space of the collapsing cavity. Fig. 1: gas phase diagram

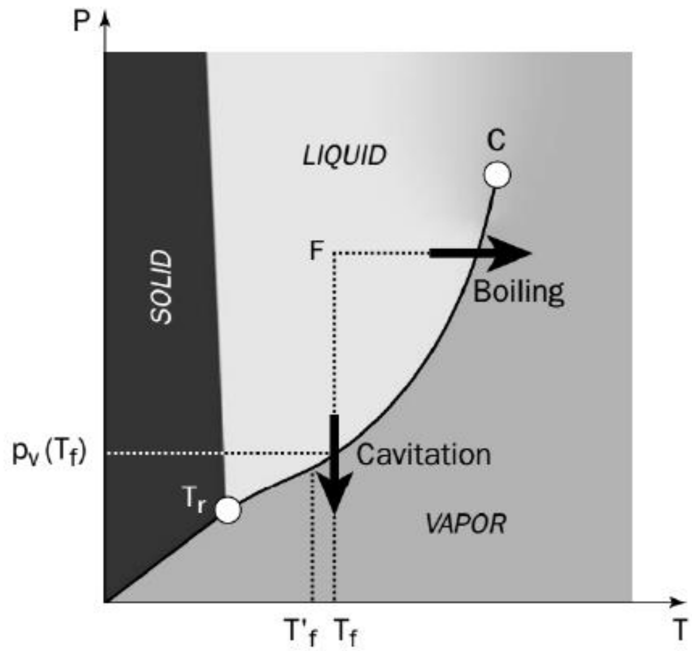

Fig. 1: Gas phase diagram[7]

The products are sometimes amorphous and sometimes crystalline depending on the temperature of the liquid loop region in which the reactions occur.[3-4] The temperature of this liquid ring is less than the temperature inside the bubbles; while exceeding the bulk liquid temperature. in summary, the size, shape, and structure of the solid phase (amorphous or crystalline) are different in all the sonochemical reactions used for the production of nanomaterials. The ultrasonic cavitation can be defined as a combinational phenomenon of bubble formation, growth, and bursting, and collapse in the liquid media. Ultrasonic emulsifying was first reported in 1927. The nano-emulsion production by ultrasound waves involves a two-step mechanism. In the first stage, the initial drops are formed where the sound field generates the spatial waves; their instability will result in the eruption of the oil phase into the water in the form of drops. The second stage involves the fracture of the initial drops where the sonic cavitation results in severe turbulence and shear forces giving rise to the burst of the bubbles in an asymmetric manner. This will produce micro-jets which will effectively promote the fracture of the oil drops into the nanometer scale. The first step of the droplet fracture is controlled

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by the type and level of the shear force applied to the droplets. The droplet resistance against deformation is determined by the surfactant. [5-6-7]In the second stage (droplet combinations) the surfactant absorption rate is controlled by the surface activity and the surfactant concentration. The selection of a proper surfactant plays the most important role in the formation of high-stability nano-emulsion. HLB (hydrophilicity-lipophilicity balance) is an applicable parameter in the selection of the surfactant (surface-active substance). HLB is an empirical parameter reflecting the hydrophilicity or hydrophobicity of the surfactant. The lower HLB values are indicative of higher lipophilicity; while higher HLB levels show more hydrophobicity of the surfactant and its water solubility. Generally, surfactants with HLB values in the range of 2-7 are used to form a water-in-oil emulsion. Whereas the formation of oil-in-water emulsions required surfactants with HLB values of 8-16. Numerous studies have shown that ultrasonic emulsification is a proper, cost-effective, and feasible method to produce pharmaceutical-grade nano-emulsion. The Eucalyptus oil has been used as an anesthetizer, mucoactive, anti-fever, and anti-parasite drug. It has been also used to treat respiratory diseases such as shortness of breath, asthma, and Tuberculosis.[8-9-10]

In this research, ultrasonic waves were used to extract the effective pharmaceutical agents of thyme and Eucalyptus whose compositions were then evaluated by gas chromatography.

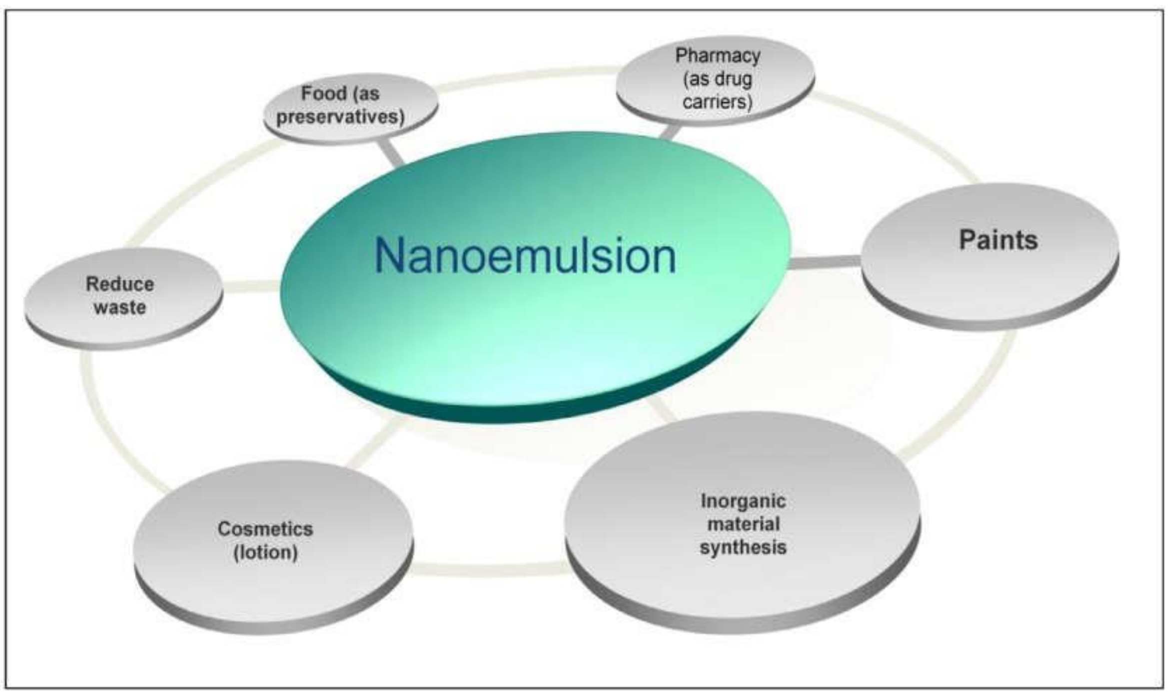

Figure 2: Applications of nanoemulsion[8]

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METHODS:

Before extraction, 5 g of the samples were placed in an oven at 70°C for 48 h to measure their moisture content. Then, 100 g dried plant was transferred into a flask to which olive oil was added (2/3 of the flask volume) followed by one hour of ultrasonication. The essential oils from different organs of the plant entered the base oil. After ultrasonication, the plant residues were filtered and the oil phase was poured in the glass containers and kept in the refrigerator till GC analysis.

CHROMATOGRAPHY ANALYSIS OF THE COMPOUNDS

To analyze the compositions of the plant extracts, a gas chromatography apparatus equipped with mass spectroscopy (MS/GC) was employed. The samples were injected into the apparatus under similar conditions to determine their compositions. The GC device model was Agilent 6890 while the MS device model was Agilaent 5973 with a 30-meter column and an internal diameter of 0.25 mm and thickness of 0.25 µm (MS-5HP). The applied mass spectrometer (Agilent 2273) operated at the ionization voltage of 70 eV through EI ionization and the ionization source temperature of 220°C. The spectra were identified according to their inhibitory indices and their comparison with the indices of the available literature as well as the mass spectra of the standard compounds in the relevant computer-based databases.

RESULTS AND DISCUSSIONS

The increase in the drug-resistant strains of viruses in recent years has increased the importance of natural antiviral compounds with lower side effects.The application of medicinal plants will result in lower side effects as compared with the chemical drugs and is more cost-effective.[9-10]Eucalyptus is a member of Myrtaceae with diverse therapeutic effects including antibacterial and antifungal properties.Thyme is one of the major genera of Lamiaceae and one of the most famous genera of the essence-containing plants. This plant can be mainly found in the Mediterranean regions, Asia, South Europe, and North Africa. This genus includes 300-400 species. In Iran, 18 species of this genus have been found which grow in different regions.45 compounds were identified in the essential oil obtained from different parts of Thymus kotschanus, the main compounds were carvacrol (52.4%), thymol (10.4%), and gamaterpinene (10.12%), accounting for 74.2% of the total composition.The results of the study on the chemical composition of thyme essential oil in the present research aresomewhat consistent with other studies conducted by other researchers. [11-12-13]Based on the standards, the amount of cineol content of the Eucalyptus leaves was higher than 70% which is of crucial importance in pharmacy. Due to the proximity of cineole contents of two species of eucalyptus to the standard levels, these species can be considered for the production of essential oils (some species collected from different parts of the world have shown essential oils contents even below 20%).

CONCLUSION:

As the quality and quantity of the essential oil of a particular species vary by the essential oil extraction season, geographical region, and place of cultivation, this extraction method can be more efficient than conventional techniques in terms of production time while maintaining the effective plant compounds.

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DISCLAIMER:

The method of processing medicinal plants with a case study of Thymus vulgaris and Eucalyptus with the help of cavitation phenomenon and ultrasonic energy is part of the research of Co Aitin Nazho Cellulose Nita.

This short research article is only to introduce the phenomenon of cavitation and its effect on the extraction of effective plant substances and is very useful in the industry of processing products from medicinal plants. The results have been evaluated in a library with the results mentioned by other researchers. The responsibility for the commercial activities of this manuscript rests solely with the authors of the work and the representatives of Co Aitin Nazho Cellulose Nita.

Also, the Journal Authorities will not have relation at any time to commercial pursuits related to this manuscript.

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