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Preface

Trends in sonochemistry and sonoprocessing in North America – Preface

Web of Science Core Collection has indexed 400 000 articles that mention ultrasound in the search criterion *Topic*. The earliest articles were published in 1931 and the technique has grown tremendously with over 30 000 mentions in articles published in 2021. In 2020 and 2021, the medical disciplines refer to US the most starting with radiology nuclear medicine as medical imaging (8914 articles), general internal medicine (5246), surgery (4123), obstetrics gynecology (4063), cardiac cardiovascular systems (3320), and oncology (2843). Outside of medicine, physics (acoustics) and electrical electronic engineering (4257 and 2244, respectively) are the other two fields that mention it often. One-sixth of the articles published in 2021 were (co–)authored with researchers from Canada, USA, and Mexico. Of these, 1700 were in engineering fields: food science & technology (346 articles), multidisciplinary chemistry (330), multidisciplinary materials science (294), nanoscience & nanotechnology (183), applied physics (178), instruments & instrumentation (176), and chemical engineering (136).

A bibliometric map of the 100 most cited keyword grouped research into 4 clusters (Fig. 1). The red cluster had the most keywords (33) centered on nanoparticles (NP). Although the database specifically excludes medical and electrical engineering topics, many keywords in the red cluster deal with medicine and applications: cancer, diagnosis, therapy, drug delivery, blood brain barrier, in vivo, and in vitro. An article in this series deal with nano particles: Girard et al. analyzed the rheological behavior of sonicated nanocellulose suspensions. They varied ultrasonic power density (2–167 kJ $g^{-1}L^{-1}$) and treatment time (3–10 s). Higher ultrasound densities resulted in better nanocrystal dispersion. However, the authors noted that sampling volumes withdrawal methods may bias the results and concluded that a continuous setup to treat dispersion gradually may be best to suspend nanoparticles [1]. Yamanaka et al prepared supersaturated Ga-Al microparticles (D = 1.7 μm) et Al^{3+}-γGa_2O_3 (D = 59 nm). The very rapid generation and extinction of hot-spots permitted to prepare a supersatured material, which confirms sonication ans a rapid and greener synthesis methods for these particles [2].

The green cluster (30 keywords) has many topics related to water and wastewater treatment and includes TiO_2, aqueous solutions, removal, and reaction engineering (kinetics, oxidation, reduction, adsorption, and T—temperature). In this special issue, Ansari and Kirpalani discuss the mechanism of ultrasound decontamination of water from naphthalene acid compounds after bitumen extraction, which are related to the green cluster. Benzoic acid fully degrades at 378 kHz with an input power 304 W and treatment times between 5 min and 4 h. More complex cyclic hydrocarbons undergo hydroxylation and degradation. The mechanism is critical for unit operation design [3]. Shende et al. targeted perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS). They calculated the observed pseudo-first order kinetic constant at ultrasound power densities from 30 to 262 W/L with and without bubbling Ar in the solution (to stimulate cavitation). High power densities fully degraded both components in 60 min. The Authors discuss the mechanism of degradation with and without the presence of an oxidant such as periodates or persulphates [4]. Kohan et al. studied the release of polycyclic aromatic hydrocarbons (PAHs) from contaminated creosote sediments enhanced by ultrasounds. They sonicated a sample of 1.4 g with 20 kHz ultrasounds at a power of 431 WL^{-1}. Ultrasound halved the extraction time (10 min versus 20 min) compared to simple agitation, as it improves local mass transfer. The authors also confirmed SPME analyses to be reproducible and robust for this kind of assessment [5].

Chemical engineering concepts are also frequently mentioned like mass transfer, functional properties, polymers (rheology), food, and physico-chemical properties are the subjects of the blue cluster with 21 keywords. Here, Martínez-Ramos et al. developed a new expression for the Nusselt number to account for the contribution of ultrasound. They demonstrate with experimental evidence and various geometries that the apparent Nusselt number may be expressed as the sum of two contributions, one of which is attributed to cavitation-acoustic streaming effects ($R^2 > 0.8$) [6]. Laajimi et al. measured, by electron paramagnetic resonance, the radical generation in organic solvents in the presence of silica particles – 10 nm, 0.25 μm, and 19 μm – and concentrations – 0.5 % and 3 % by mass. They discuss the mechanism and how to maximize radical formation in the solution, with important consequences for sonocatalysis [7]. Ehsani et al. studied instead cavitation for fouling remediation. In their experimental plan, they employed synchrotron in-line phase contrast imaging and a high-speed camera to visualize, count, and determine the dynamics of US-generated microbubbles in water at US frequencies of 20, 28 and 40 KHz at 60 W. The readers will find a newly developed correlation to estimate the growth rate of large bubbles (>10 μm) [8]. Li et al studied the effect of ultrasound on molten aluminum droplet spreading on SiC, a process of great interest in the field of automotive and electronics. Ultrasounds (20 kHz) help spread Al in 10 s and impact the alumina (oxide) layer formed on the surface of the droplet [9].

Anti-oxidant is the topic mentioned most often (169 articles) and dominates the yellow cluster (keywords). This cluster has several topics that relate to food and food extraction such fruit, as flavonoid, bioactive compounds, polyphenols, anthocyanin, and micro-wave and ultrasonic extraction. Herrera-Pool et al. extracted phenolic compounds from habanero pepper leaves (*Capsicum chinense)* with the aid of ultrasound. They designed a 2x10 factor set of experiments and varied solvent polarity and individuated the best solvent that gave the optimal recovery

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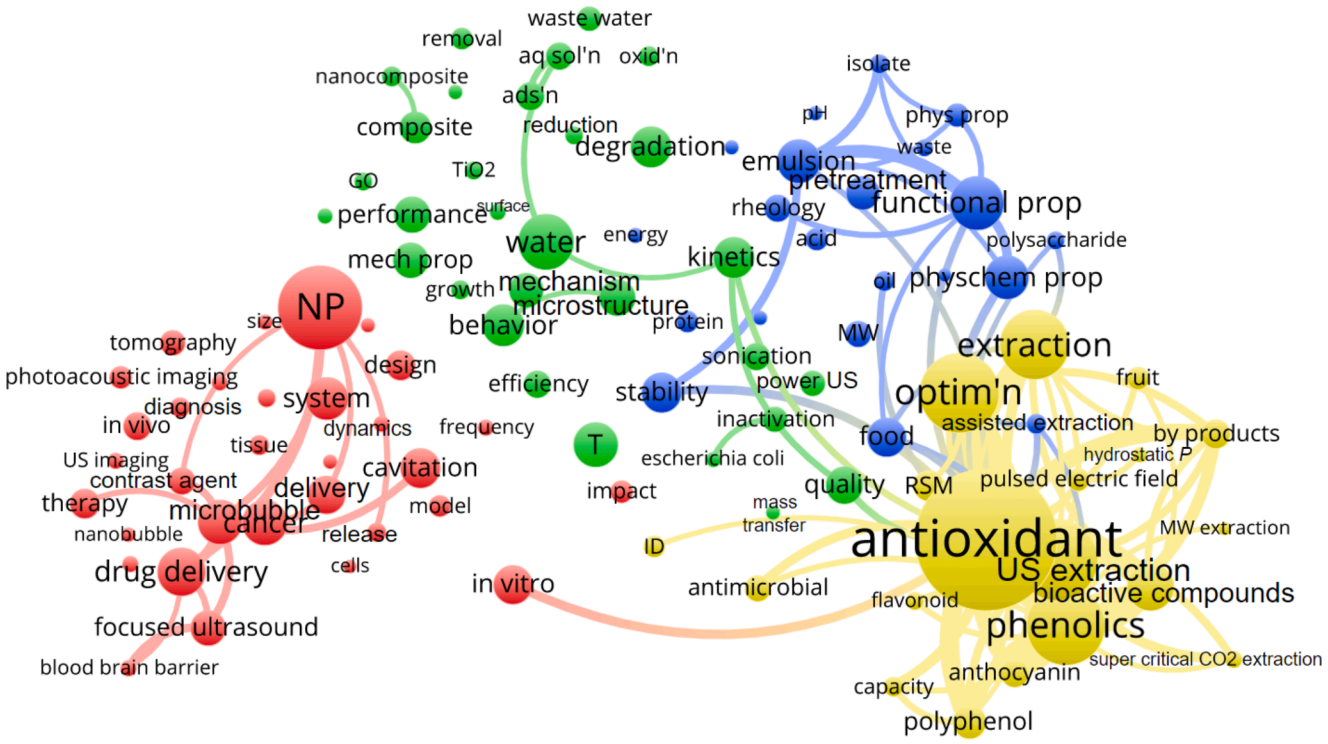

Fig. 1. VoSViewer bibliometric map of the 100 most frequent keywords from 1700 articles published by NA researchers excluding medical and electrical engineering fields (Web of Science, 2020–2021). The size of the circles correlates with number of occurrences: the smallest represent 16 articles. Keywords in the same cluster (same colour) frequently appear in the same articles. The lines relate to the number of citations between articles. The red cluster has 32 keywords, and the NP (nanoparticles) appears in 1000 of the 1700 articles in the sample. The green cluster has 30 keywords and water is in 66 articles. Functional properties occur most often in the blue cluster that has 21 of the top 100 often mentioned keywords. The most frequent keyword cited in the database is antioxidant (169) in the yellow cluster, which has 19 keywords. Abbreviations: ads'n = adsorption, aq sol'n = aqueous solution, GO = graphene oxide, MW = microwave, NP = nanoparticle, optim'n = optimization oxid'n = oxiation, prop = properties phsychem = physicochemical red'n = reduction, RSM = response surface methodology, T = temperature, and US = ultrasound.

[10].

Lomonaco Teodoro da Silva et al. employ high intensity ultrasound to change the physicochemical properties of palm olein. The authors evaluated two levels for agitation and temperature and three different positions of the ultrasound probe. Cavitation promoted nucleation, and had a significant effect on hardness and viscosity of the solid material depending on the position of the probe in the process [11].

Tabio-García et al. optimized the extraction of polyphenols and betalains (a red pigment) from a tropical plant (*Amaranthus hypochondriacus)*. Temperature (20–54 °C) and ultrasonic power density (76–274 W/L, frequency 20 kHz) were the variables that were optimized, while solute–solvent ratio and pH were constant (1:30 and 5, respectively). Maximum yields of 83 % and 21 % for pigments and antioxidants were achieved and confirm ultrasound as a fast and effective method for high added value extraction method from biomass matter [12].

Amador-Espejo et al. studied thermal (50–60 °C) and ultrasound treatment (24 kHz, 400 W nominal power, 2–6 min) to improve the quality of low-fat Panela cheese. Even though microbiological and microstructural tests might be needed to validate the results, the authors demonstrate that the thermosonic method maintains cheese yield, syneresis, water content, texture profile, color, and titratable acidity statistically similar to the full-fat cheese variety ($p < 0.05$) [13].

Haque et al. treat microalgal biomass with ultrasound (20 kHz, 750 W, 50 % amplitude) to recover secondary metabolites in very short times (5–30 min). After 30 min the recovered metabolites were 6.4 times higher than the non-ultrasonicated sample. Acoustic cavitation disrupted cell membranes leading to a faster release of metabolites, as it was evident through the total chlorophyll content of the ultrasonicated microalgal samples and the microscopic images of the ruptured cells. The extractant demonstrated activity as nematicide against root-knot nematodes, with up to 100 % inhibition [14].

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