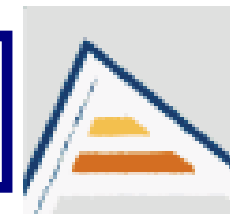


SONOCHEMICAL STUDY OF TETRACHLOROETHYLENE AND ITS NON-VOLATILE CHLORINATED REACTION BYPRODUCTS

**M. D. Esclapez, V. Sáez, P. Bonete, J. González-García, A. Fakouri,
M. Schulz and A. Rehorek**

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Introduction

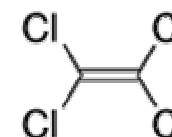
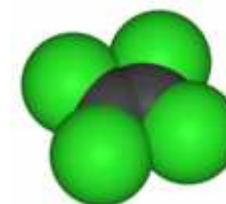
PERCHLOROETHYLENE (PCE)

- Industrial grease remover
- Water disinfection by-product
- Dry cleaning
- Paper industries

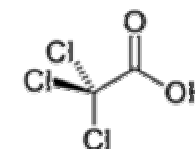
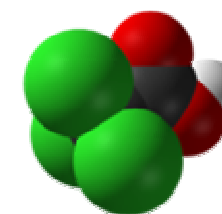
TRICHLOROACETIC ACID (TCAA)

- Used as pesticide in last century
- Water disinfection by-product
- Paper industries
- Industrial reactions intermediate
- Solar degradation of PCE

Properties	PCE	TCAA
Molecular weight / g mol ⁻¹	165.83	163.39
Melting point / °C	-19	54
Boiling point / °C	121	196
Solubility in water at 25°C / g L ⁻¹	0.150	81.7
Vapor pressure / mmHg	18.5	0.14
Henry's law constant at 25°C / atm m ³ mol ⁻¹	1.8·10 ⁻²	1.38·10 ⁻⁸

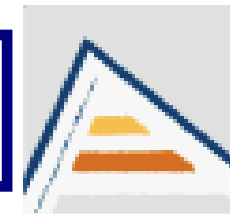


PCE



TCAA

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Introduction

Pollutant properties determine the sonochemical reaction site

PCE

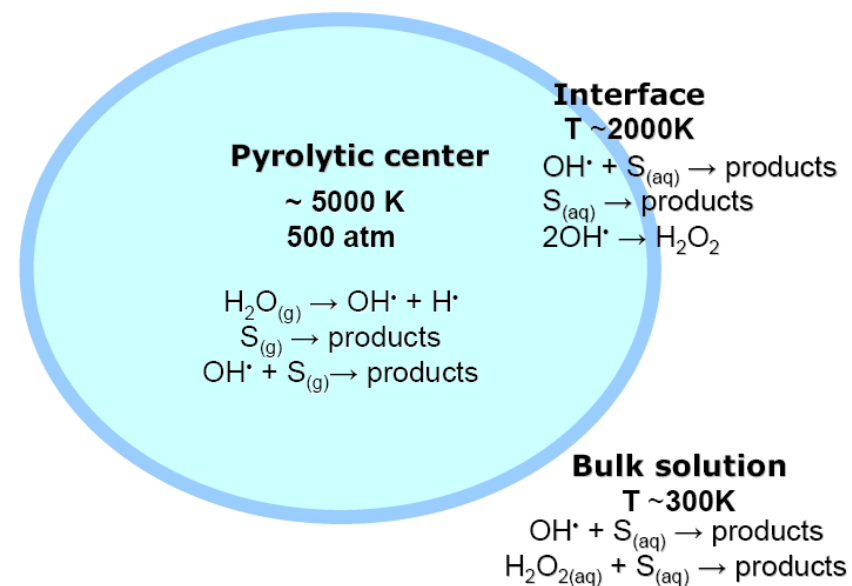


*Volatile
Low solubility
Hydrophobic*

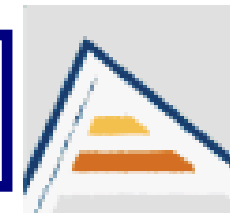
TCAA



*Non volatile
High solubility
Hydrophilic
Acidic behaviour*



SONOCHEMICAL STUDY OF TETRACHLOROETHYLENE AND ITS NON-VOLATILE CHLORINATED REACTION BYPRODUCTS



Experimental

Sonochemical systems



Undatim
sonoreactor, 20 kHz

Meinhardt
sonoreactor, 850
and 378 kHz



Analytical procedures

IC: Basic IC 792 System (Metrohm). Cl^- , NO_3^- , NO_2^- , chloroacetates



HPLC: L7000 LaChrom (Merck-Hitachi), DAD detector.

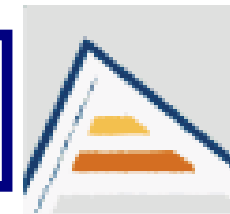
- Chloroethenes
- Chloroacetates



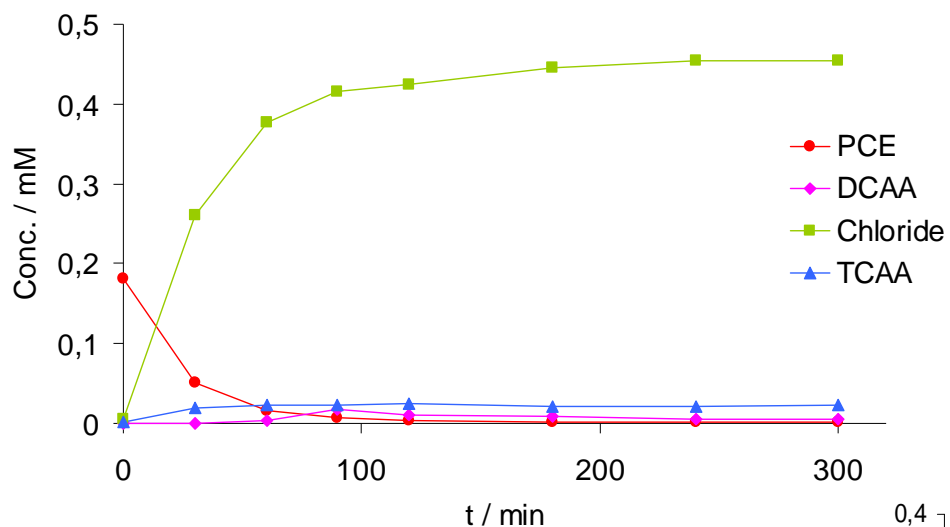
CG: gas phase monitoring. FID, TCD or MS detector for PCE reactions



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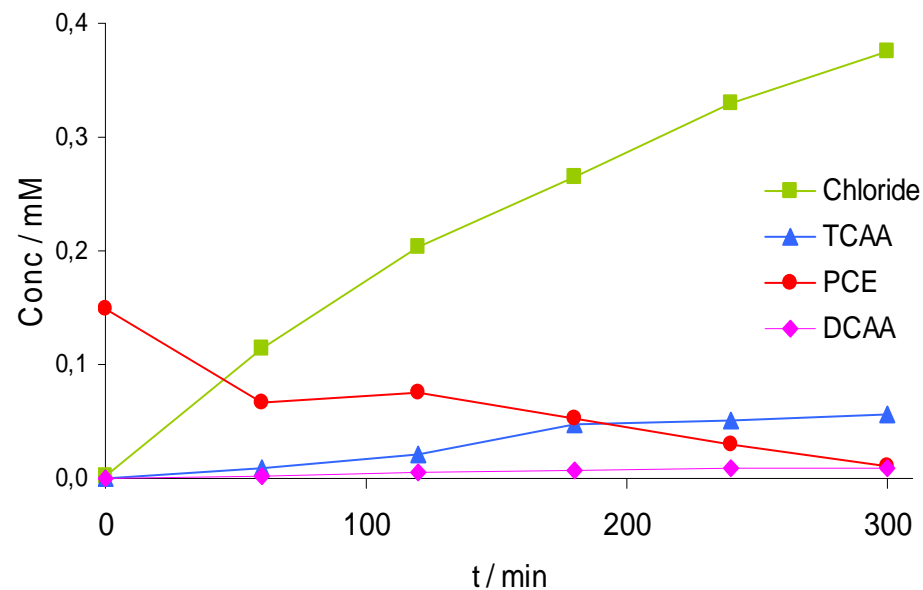
Sonochemical degradation of perchloroethylene



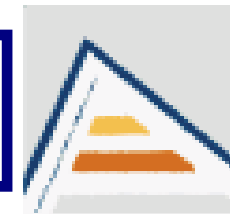
280 mL 20 kHz, a 44 W, 0.168 W cm⁻³ and 20°C

1900 mL 850 kHz, a 24 W, 0.047 W cm⁻³ and 20°C

Chloroacetic acids by radical mechanisms



SONOCHEMICAL STUDY OF TETRACHLOROETHYLENE AND ITS NON-VOLATILE CHLORINATED REACTION BYPRODUCTS



Sonochemical study of trichloroacetic acid in aqueous solution

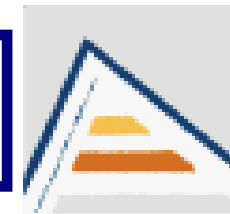
- TCAA as a **product** of sonochemical degradation of PCE
- ¿Can TCAA be sonochemically degraded?



Research group Prof. Dr. Astrid Rehorek

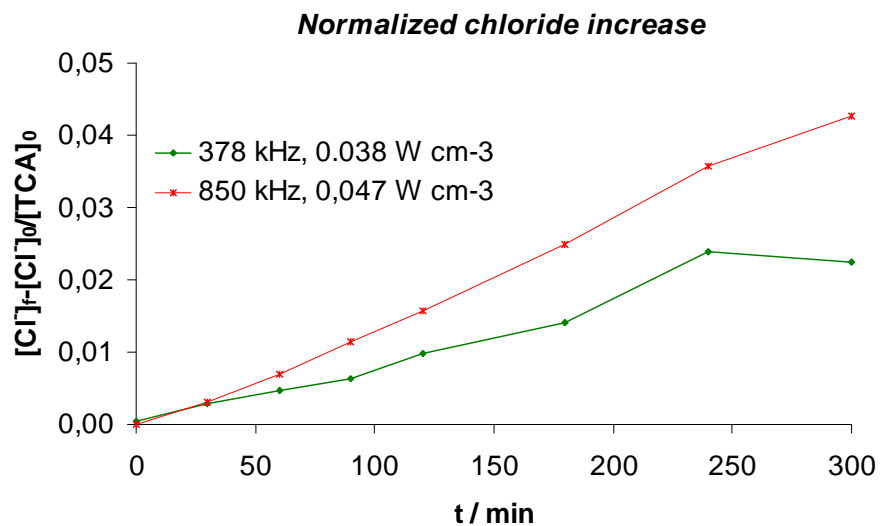
- *Frequency effect*
- *Temperature effect*
- *Gas solved effect*
- *Reaction mechanisms*
- *Physicochemical properties*

SONOCHEMICAL STUDY OF TETRACHLOROETHYLENE AND ITS NON-VOLATILE CHLORINATED REACTION BYPRODUCTS



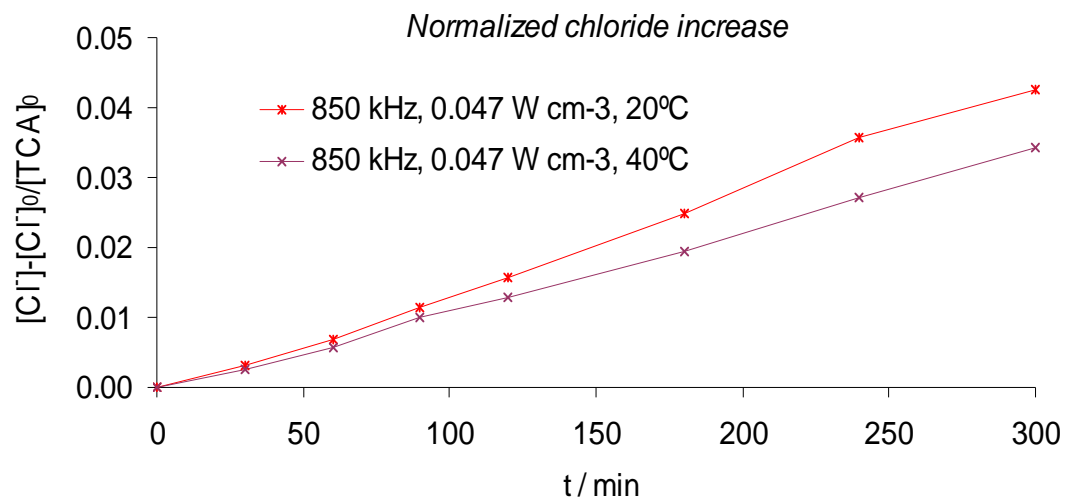
Sonochemical study of trichloroacetic acid in aqueous solution

Frequency effect



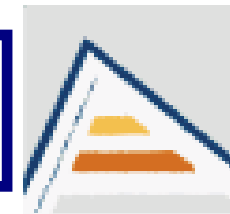
Initial concentration of TCAA was 0.5 mM in a 500 mL reaction cell

Temperature effect



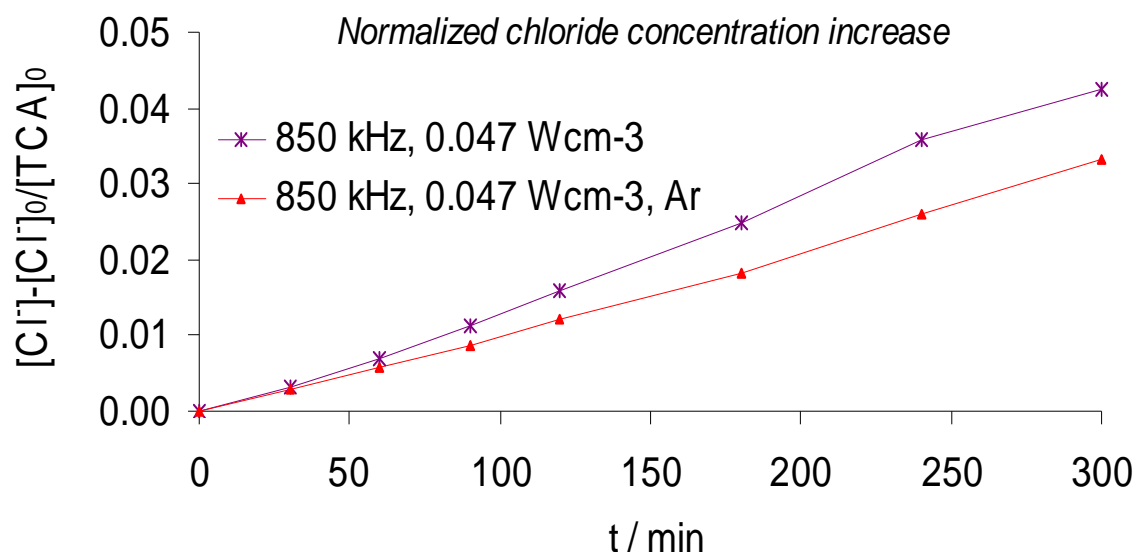
Cushioning effect of the solvent

SONOCHEMICAL STUDY OF TETRACHLOROETHYLENE AND ITS NON-VOLATILE CHLORINATED REACTION BYPRODUCTS



Sonochemical study of trichloroacetic acid in aqueous solution

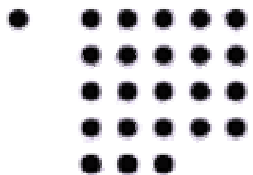
Gas dissolved effect



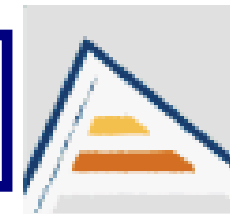
Gara et. al reported the reactivity of TCAA with radical $O_2^{\cdot-}/HO_2^{\cdot}$ in aqueous solution

Fenton reactions

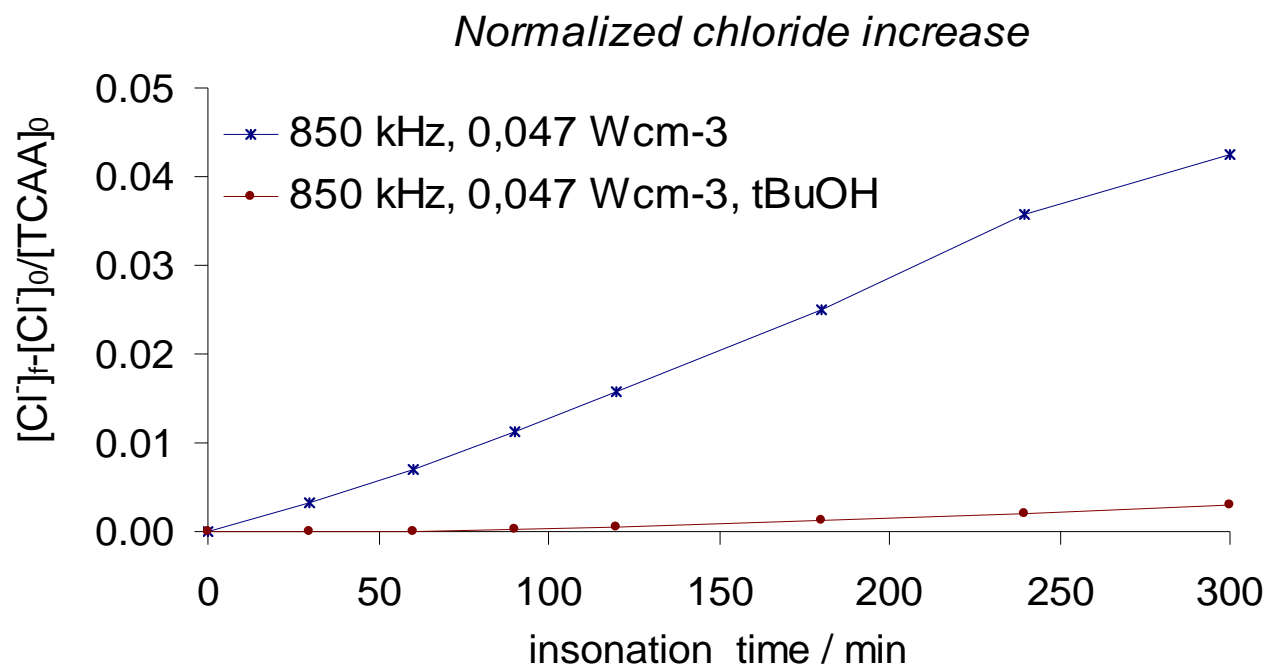
	Ar	O ₂	Air	N ₂
H ₂ O ₂ (μmol dm ⁻³ min ⁻¹)	0.85	0.69	0.60	0.11
Cp/Cv = γ	1.66	1.39	1.4	1.40



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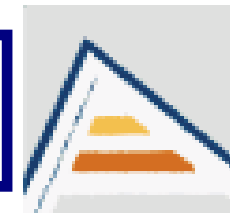
Sonochemical study of trichloroacetic acid in aqueous solution



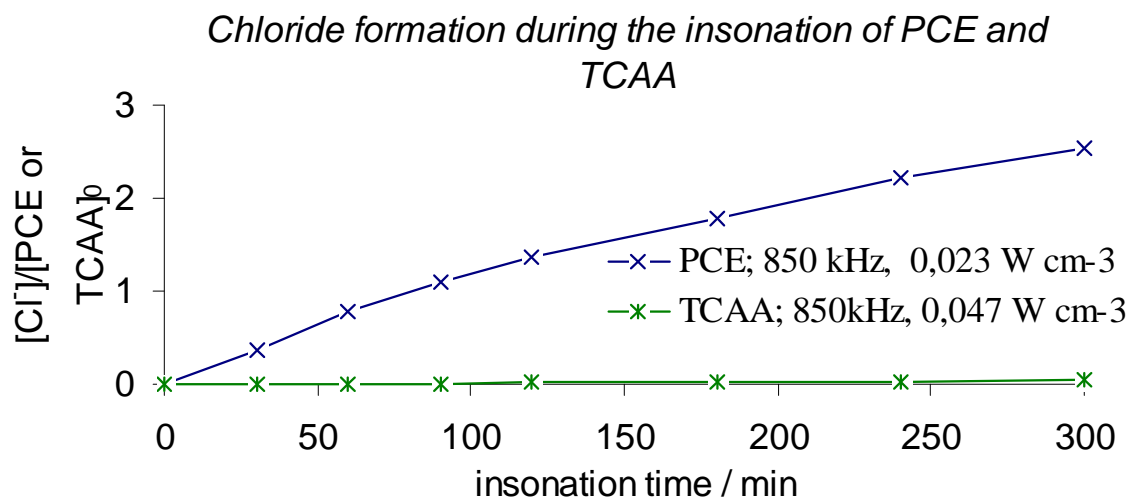
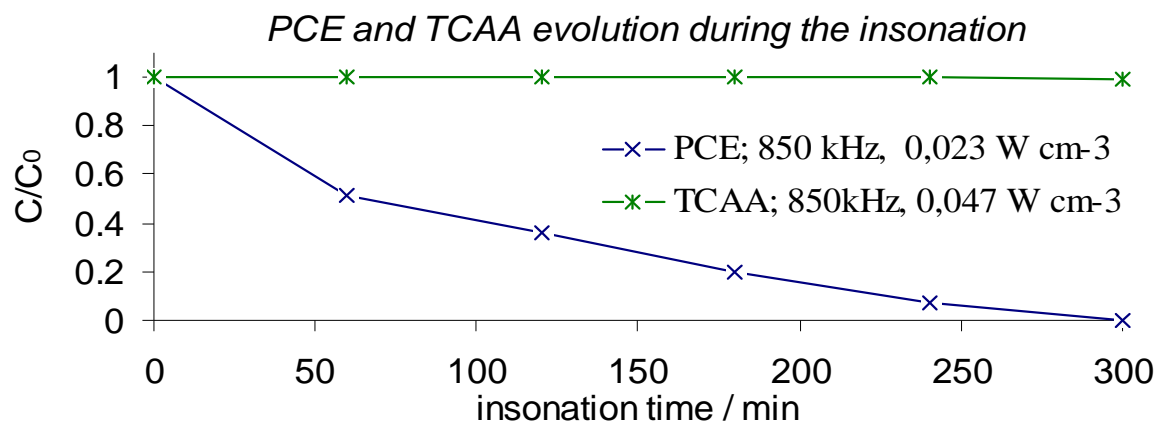
Mechanism of reaction

The reaction with a radical scavenger (t-butanol 50 mM) in the solution inhibits the C-Cl breakage in a high degree.

SONOCHEMICAL STUDY OF TETRACHLOROETHYLENE AND ITS NON-VOLATILE CHLORINATED REACTION BYPRODUCTS



Comparison between perchloroethylene and trichloroacetic acid degradation



Physico-chemical properties

The low degradation rate of TCAA contrasts with the PCE behavior, as a direct consequence of the difference in volatility and its hydrophobic character

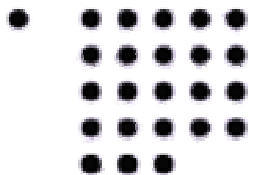


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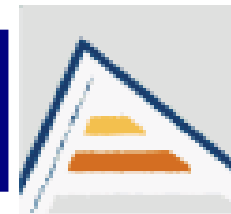


Conclusions

- *PCE* readily penetrates into the bubble where is efficiently dechlorinated, but also chloroacetic acids are formed
- *TCAA* usually appears in industrial waste water together with *PCE* as a product of its natural degradation but its **hydrophilic nature** does not allow the accumulation in the liquid-vapor interface, which **avoids the effective mineralization** in a sonochemical treatment
- The slow degradation of *TCAA* is in a significant extend the result of a **radical mechanism**



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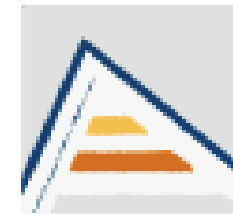
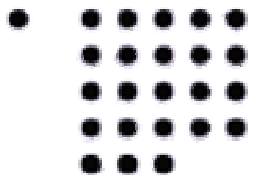


Acknowledgement

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