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Influence of filtration and addition of nanoparticles on the Non-Photochemical Laser Induced Nucleation of EthyleneDiamine Sulfate

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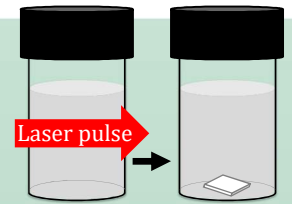
HAL Authorization

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Context

NPLIN stands for **N**on-**P**hotochemical **L**aser **I**nduced **N**ucleation.

- Nucleation process discovered in 1996 by Garetz *et al* (1)
- Laser pulses trigger nucleation from supersaturated solution



How does it works ?

Hypothesis of mechanism → **"Nanoparticle heating"**

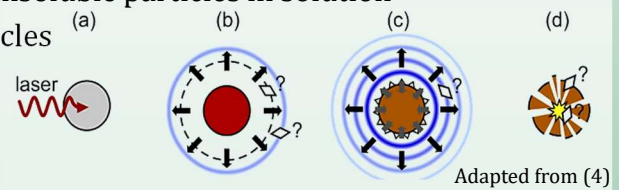
Observation : Filtration decreases or suppresses NPLIN due to insoluble particles in solution (2)(3)

(a) Absorption/diffusion of the laser pulse by an impurity particles

(b) Heating causes formation of vapor cavity => nucleation

(c) Collapse of the cavity causes pressure waves => nucleation

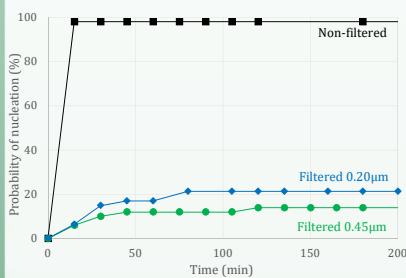
(d) Destruction of the particle



Adapted from (4)

Filtration & analysis of impurities

Preliminary test : NPLIN
 Use of PTFE syringe filter
 Pore size 0.20 and 0.45 μm

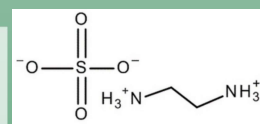


→ Size of impurities > 0.45 μm

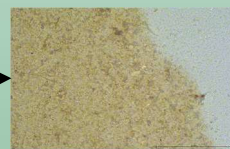
Ethylenediamine sulfate (EDS)

- 99% Purity
- Solution β = 1.10

Use of Filter membrane for analysis

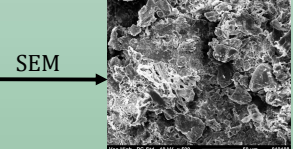


Microscopy



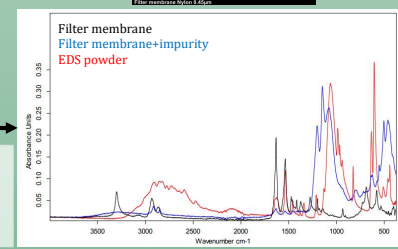
Amorphous solid

XRD



Insoluble impurities : 0.1 mg/g EDS

ATR-FTIR



Concentration

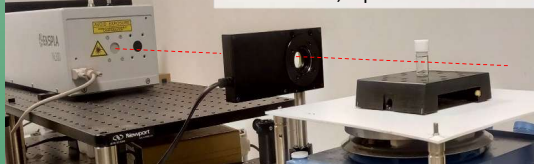
Concentration (mg/L)	Fe	Ni	Cr	S
Control	3.3	0.28	0.06	0.14
Impurity Sample	8.2	0.76	0.71	1.6

Metallic composition
 → Stainless steel

NPLIN in Doped solutions

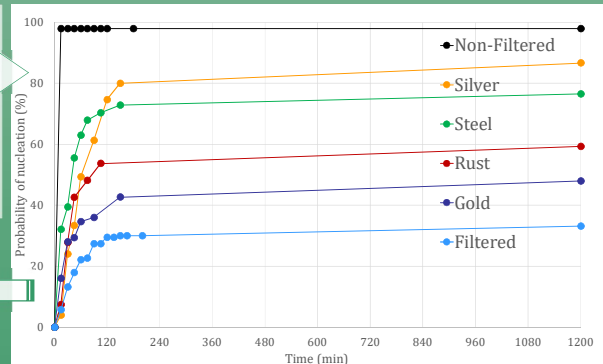
NPLIN set-up

Laser irradiation :
 1064nm, 1 pulse at 34.8mJ



Addition of Nanoparticles in Supersaturated filtered solution

- Silver nanoparticle (10nm)
- Gold nanoparticle (10nm)
- Stainless steel 316L
- Rust from 316L steel



The kinetic behavior of NPLIN differs for the four particles tested

→ Different **absorption/ diffusion** properties of the tested particles

There is no total recovery of the initial (non-filtered) behavior, maybe due to difference in composition, concentration, dispersion of the particles.

Conclusion & Perspectives

- Filtration **decreases the probability of nucleation** and **increases the induction time** in EDS solution
- Filtration removes **insoluble solid impurities**, that could come from industrial production => stainless steel rust ?
- The initial behavior can be partially retrieved by intentional addition of particles in the solution.

PERSPECTIVES : Possibility for compounds that do not exhibit NPLIN to nucleate by addition of particles.

References

- (1)Garetz, B. A.; Aber, J. E.; Goddard, N. L.; Young, R. G.; Myerson, A. S. *Physical review letters* 1996, 77 (16), 3475.
- (2)Javid, N.; Kendall, T.; Burns, I. S.; Sefcik, J. *Crystal Growth & Design* 2016, 16 (8), 4196–4202.
- (3)Ward, M. R.; Mackenzie, A. M.; Alexander, A. J. *Crystal Growth & Design* 2016, 16 (12), 6790–6796.
- (4)Alexander, A. J.; Camp, P. J. *J. Chem. Phys.* 2019, 150 (4), 040901.