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STUDY OF THE BEHAVIOUR OF YSZ DISPERSIONS IN WATER

M. Della Negra, C. Knöfel, K. Tydén, M. Wandel

Motivations:

Better understanding of the behaviour of yttria fully stabilized zirconia in water for applications in wet ceramic processing

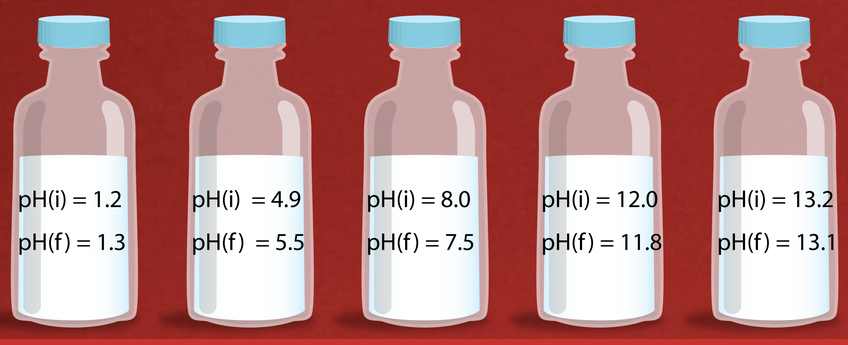
Questions:

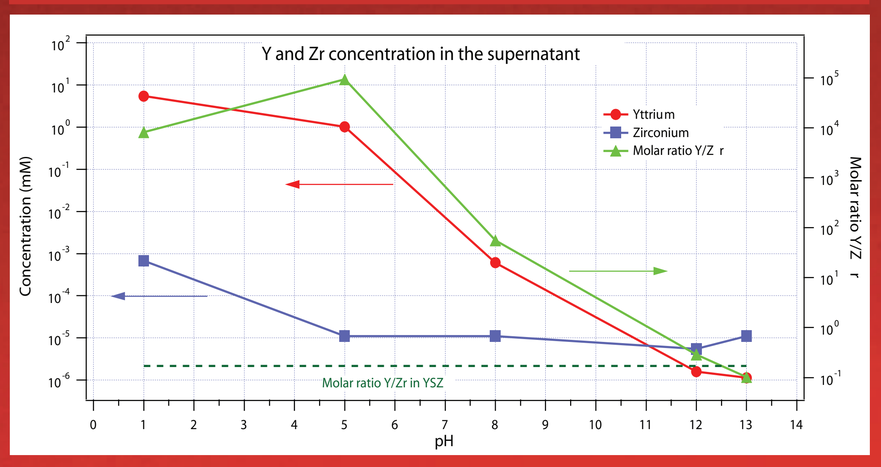
Are Y^{3+} and Zr^{4+} leaching in solution from the cubic structure?
Is the particle surface affected?
Are the particle structure and composition affected?

Long term treatments in water at different pH

YSZ solid load: 40% in mass.
pH adjusted with HCl or NaOH
3 weeks treatment

Supernatant and powder separated by centrifugation
Liquid phase analyzed with ICP





Y^{3+} dissolves in water in acidic environment. The amount of Y^{3+} found in the supernatant increases with acidity.

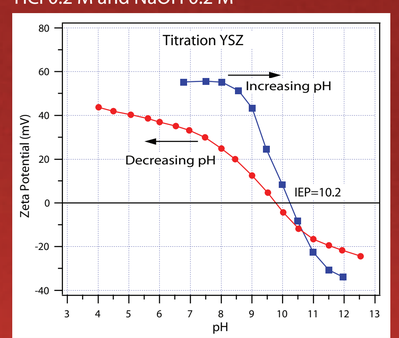
Zr^{4+} leaches in solution only at low pH.

In the acidic range the molar ratio Y/Zr in the supernatant is much higher than it is in the YSZ powder, proving actual dissolution

In basic condition the amount of the two elements in solution is extremely low.

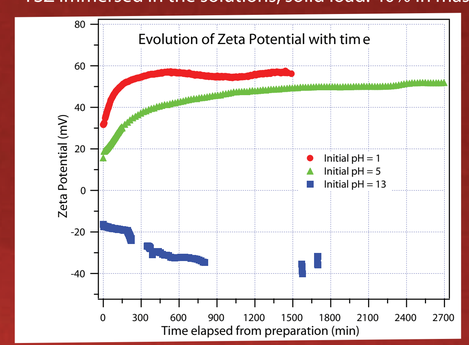
Isoelectric point

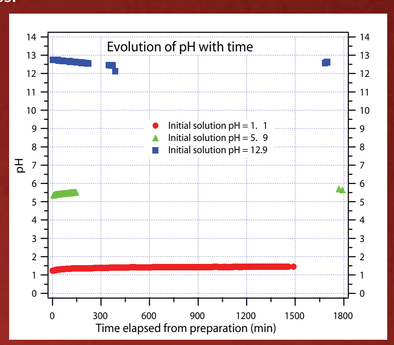
YSZ milled in water for 3 days
Solid load: 13% in mass
Titrations performed with:
HCl 0.2 M and NaOH 0.2 M



Powder potential and suspension pH

Initial pH adjusted with HCl and NaOH
YSZ immersed in the solutions, solid load: 40% in mass.





Zeta potential increases with time and reaches a plateau for native pH and pH=1.Potential is higher at low pH and increases faster.

In basic solution the potential is negative and decreases with time. The suspension is not stable and the powder tends to sediment in spite of energic stirring.

The powder acts as a base or as an acid (depending on the conditions) modifying the suspension pH. The pH reaches stability with time.

Properties of the YSZ powder	
Specificsurface area	12.9 m^2/g
Crystallite size	23 nm
Particlesize (d_{50})	0.15 µm
ZrO_2 (Mass %)	86.3%
Y_2O_3 (Mass %)	13.6%
Na_2O (Mass %)	0.07%

Conclusions:

Y^{3+} is leaching from the cubic structure in aqueous acidic solutions.

Zr^{4+} is leaching at pH=1, in smaller extent than Y^{3+}.
The amount of Zr^{4+} in solution is low in the entire pH range explored.

Zeta potential and pH of the dispersion change with time, showing that the particle surface and the solutions are modified.
The equilibrium is reached in 1-2 days, depending on the pH.
Possible issues in suspension stability during processing.

The YSZ particle structure and overall composition are not affected.

Treatments in native pH

Experimental details

8% yttria stabilized zirconia milled in water for:
1 hour, 1 day, 3 days.
Solid load: 40% in mass
2 drying procedures were tested:

Centrifugation and drying at RT
Drying in oven

The particles were analysed with:
Raman spectroscopy,
EDS and XPS (results not shown because inconclusive)

Horiba Jobin Yvon HR800 UV. Green Argon laser 514 nm.
There is no evidence of new features appearing or disappearing as effect of a new phase formation or adsorption/desorption on the particle surface.

Atomic percentage from EDS analysis			
Sample	Y at %	Zr at%	Y/Zr
Raw material	17.6±1.5	82.4±1.9	0.21±0.02
1 hour millingcentrif.	19.1±1.6	80.9±2.1	0.24±0.03
1 hour millingoven (1)	11.7±3.2	88.3±4.3	0.13±0.04
1 hour millingoven (2)	21.8±3.1	78.2±4.1	0.28±0.05
1 hour millingoven(3)	16.7±1.6	83.3±2.1	0.20±0.02
3 days millingcentrif.	19.6±1.8	80.4±2.3	0.24±0.03
3 days millingoven	18.4±1.4	81.6±1.8	0.22±0.02

In spite of the data scattering, the results of EDS analysis indicate no change in the atomic ratio between Y and Zr induced by the milling treatments in water or the drying procedure.

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