



Alvacat

High Throughput Workflows for the Synthesis of Mixed Metal Oxides

Alfred Hagemeyer, Valery Sokolovskii, Hans-Joerg Woelk
Alvacat, 320 Logue Ave, Mountain View, CA 94043

www.alvacat.com

Company Profile

- Contract research
- Heterogeneous catalysis, Materials science
- Renewables
- Environmental catalysis
- Hydrogen storage catalysis
- Energy storage, Battery materials
- Custom catalyst and support development
- Lab scale, bench scale and scale up
- Catalyst carrier and solution inventory
- High throughput synthesis and screening
- Partnered with tollers for scaleup, piloting, manufacturing and metal recycling

Discovery, Development & Commercialization



- Alvacat team includes the pioneers of high throughput catalyst screening
- Advancing powder formulations from discovery phase to shaped catalysts
- Data mining and predictive modeling using PLS and ANN
- Leverage external resources for catalyst scaleup and process development

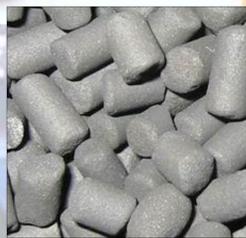
Powder Shaping

High Torque Bonnot BB Gun Extruder



The B-B Gun

- high crush strength extrudates
- mm-scale



High Throughput Synthesis Workflows

High Throughput Catalyst Development Infrastructure



Library Design → Synthesis → Surface Characterization & Iterate

Proven workflows for established synthetic routes

- (Co)-Precipitation
- Combustion synthesis (Pechini method)
- Dry decomposition
- Sol-Gel

- Universal applicability
- Tremendous diversity
- Multi metal oxides

Synthesis of High Surface Area (Mixed) Metal Oxides

Selected Results

Pechini	BET	Sol-Gel	BET	PV
NiO	400 m ² /g	Al ₂ O ₃	440 m ² /g	1.9 ml/g
CeO ₂	300 m ² /g	Al ₂ O ₃	450 m ² /g	1.7 ml/g
SnO ₂	230 m ² /g	Al ₂ O ₃	460 m ² /g	1.6 ml/g

Binary	BET
Sb-Sn-O	170 m ² /g
Zr-B-O	180 m ² /g
Zr-Ti-O	310 m ² /g

Pechini	BET
Nb ₂ O ₅	210 m ² /g
Y ₂ O ₃	220 m ² /g
Co ₃ O ₄	200 m ² /g
Mn ₃ O ₄	260 m ² /g
Fe ₂ O ₃	220 m ² /g

References

Current Catalysis, 2016, 5, 1-18
 WO 2006/119311; US 2009/0011930
 AIChE Annual Meeting 2020, San Francisco

Conclusions

High Throughput Synthesis of Porous Multi Metal Oxides

- Implemented high throughput workflows for the synthesis of mixed oxide powders
 - (co)-precipitation
 - combustion synthesis (Pechini method)
 - dry decomposition of combustible precursors
 - sol-gel
- Alvacat has experience how to adapt the micro-scale recipes to commercial scale production in state-of-art pulsation and plasma reactors