

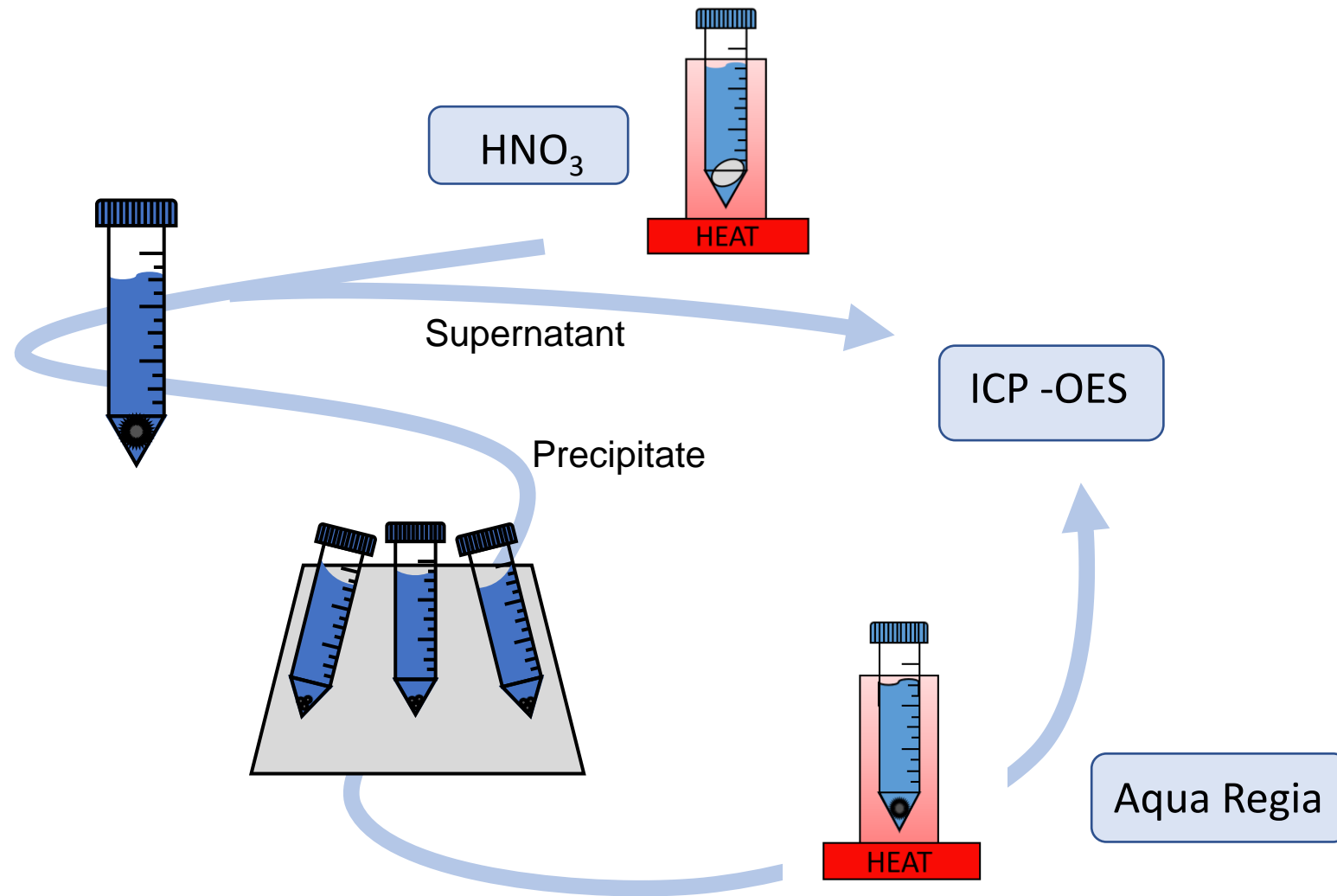


The Use of Vortex Mixing with ICP-OES for the Analysis of High Grade Silver

The LBMA Assaying & Refining Conference 2023



State of the art



ISO 15096:2020



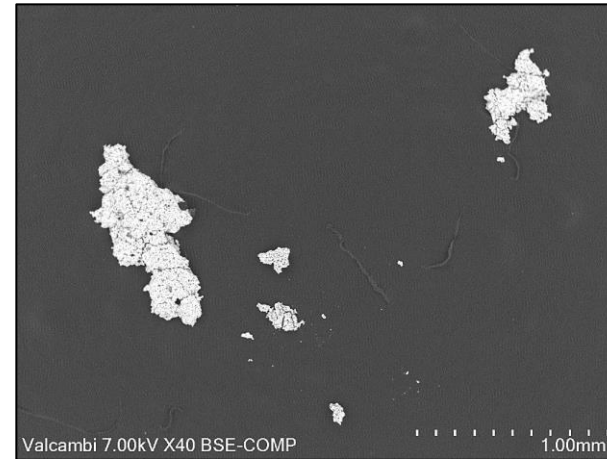
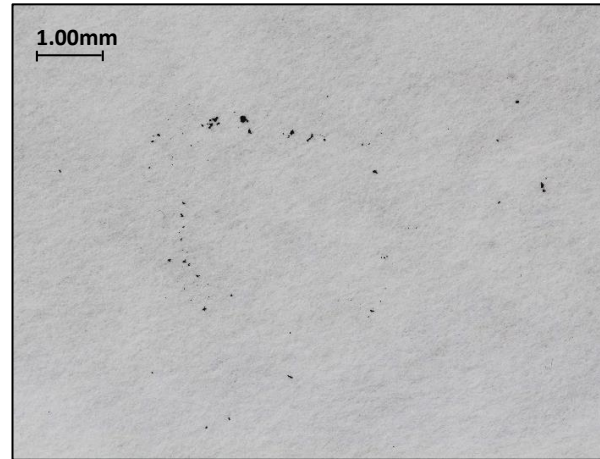
Starting point

Element	Acid	Concentration [ppm]	Std. Dev [ppm]
Pt	HNO ₃	132.4	7.0
	AR	286.8	25.3
	Total	419.2	
Co	HNO ₃	5.4	0.4
	AR	132.3	28.3
	Total	137.7	
Cr	HNO ₃	68.6	6.4
	AR	78.1	7.0
	Total	146.7	
Ni	HNO ₃	27.8	1.0
	AR	263.4	32.5
	Total	291.2	
Si	HNO ₃	12.6	0.8
	AR	117.5	18.2
	Total	130.1	

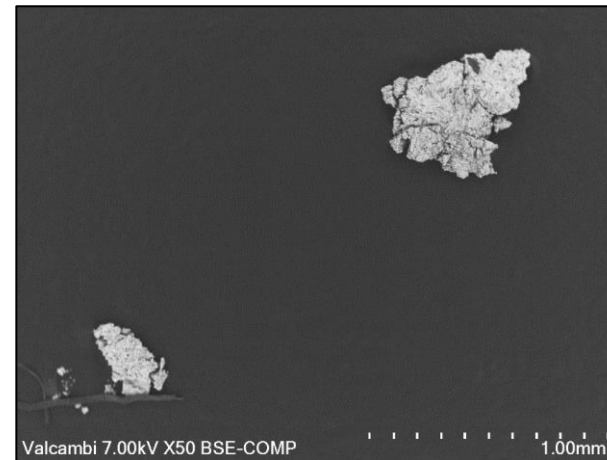
24 replicates



Starting point

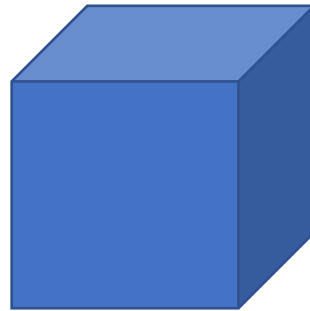


Average size dimension
361 μm

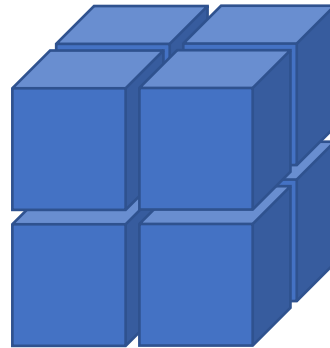


Vortex

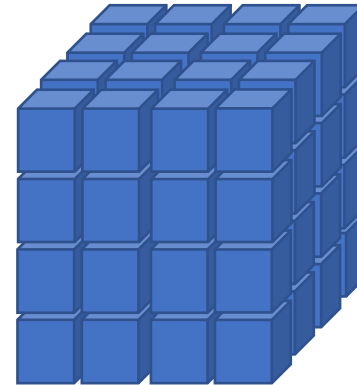
Volume 8 cm^3



Surface area
 24 cm^2



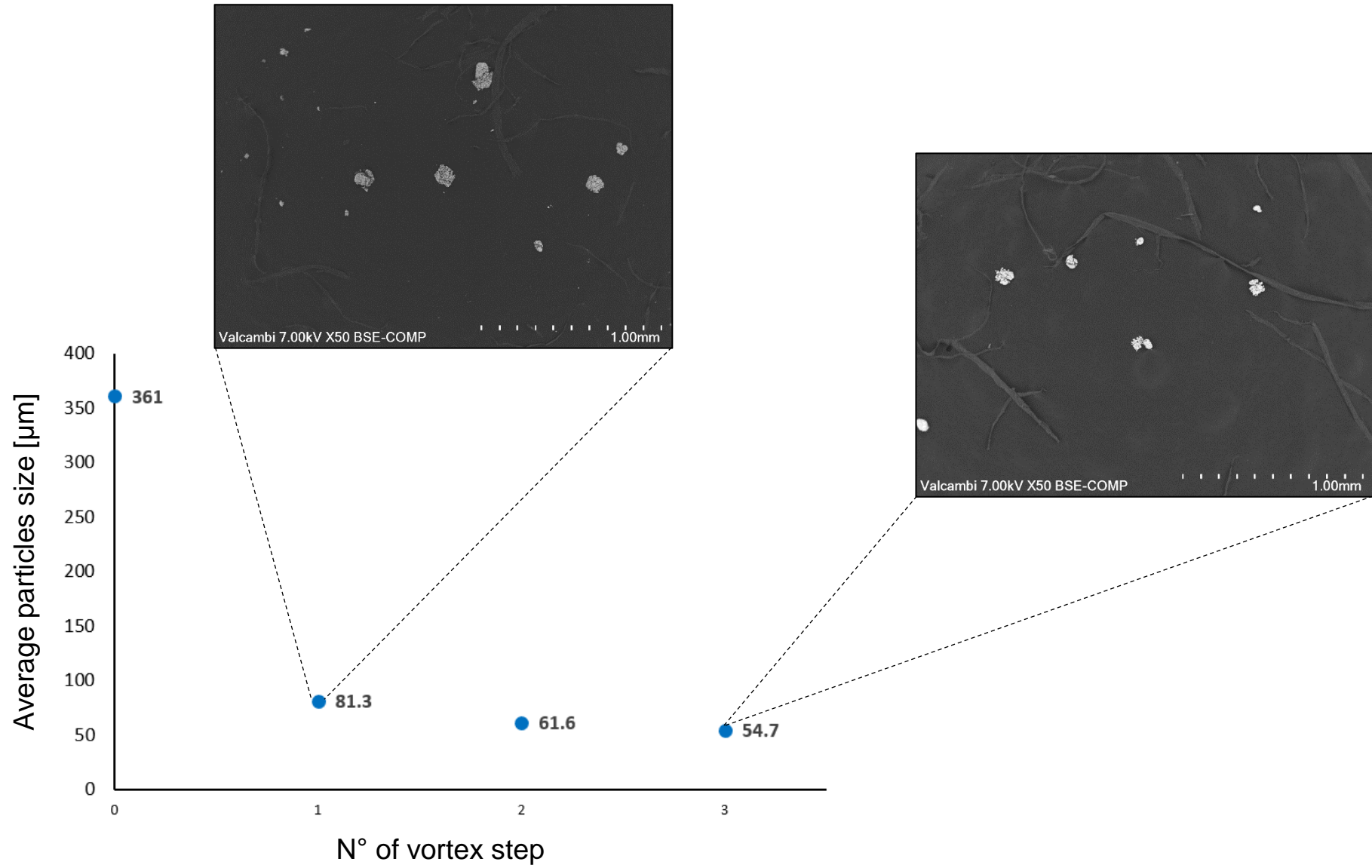
Surface area
 48 cm^2



Surface area
 96 cm^2



Vortex – particles size



Vortex – ICP-OES analysis

[ppm]		NO Vortex	Vortex
Pt	dev. std	25.3	2.1
	Δ (max-min)	69.9	5.1
Co	dev. std	28.3	1.5
	Δ (max-min)	84.5	3.3
Cr	dev. std	7	0.9
	Δ (max-min)	17.5	2.2
Ni	dev. std	32.5	3.4
	Δ (max-min)	97.0	7.0
Si	dev. std	18.2	1.6
	Δ (max-min)	48.7	3.9

!!! statistical data only for AR dissolution

24 replicates



Vortex – comparison plan

Element [ppm]	Sample A	Sample B	Sample C
Au	455	380	3
Pt	460	5	2
Rh			90
Co	150		100
Cr	155		55
Ni	360		100
Si	170		270



Vortex – comparison results

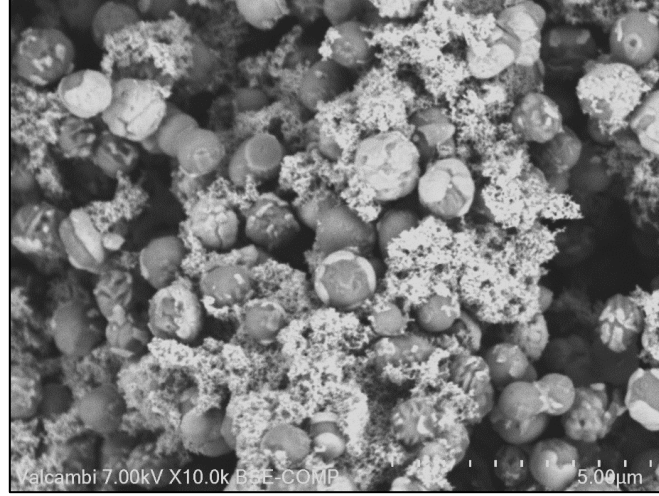
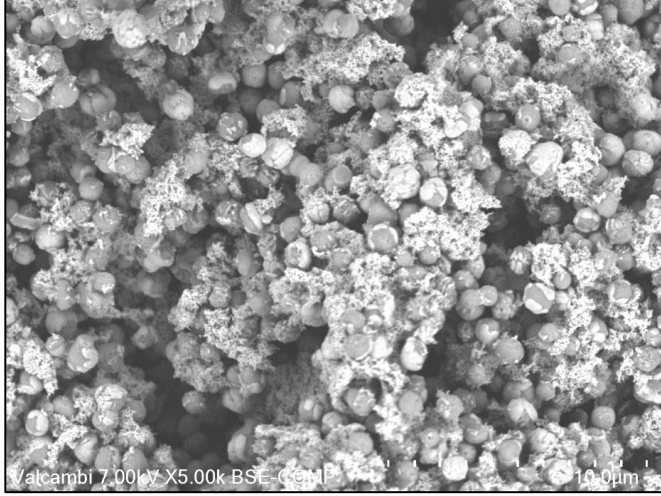
[ppm]	Std. Deviation					
	A		B		C	
	No Vortex	Vortex	No Vortex	Vortex	No Vortex	Vortex
Au	11.3	1.9	1.8	2.4	2.9	3.2
Pt	25.3	5.1	4	2.3	2.4	1.2
Rh					2.5	1
Co	28.3	3.3			2.7	1
Cr	7	2.2			0.9	0.3
Ni	32.5	7			0.9	1.1
Si	18.2	3.9			2.5	1.3

!!! statistical data only for AR dissolution

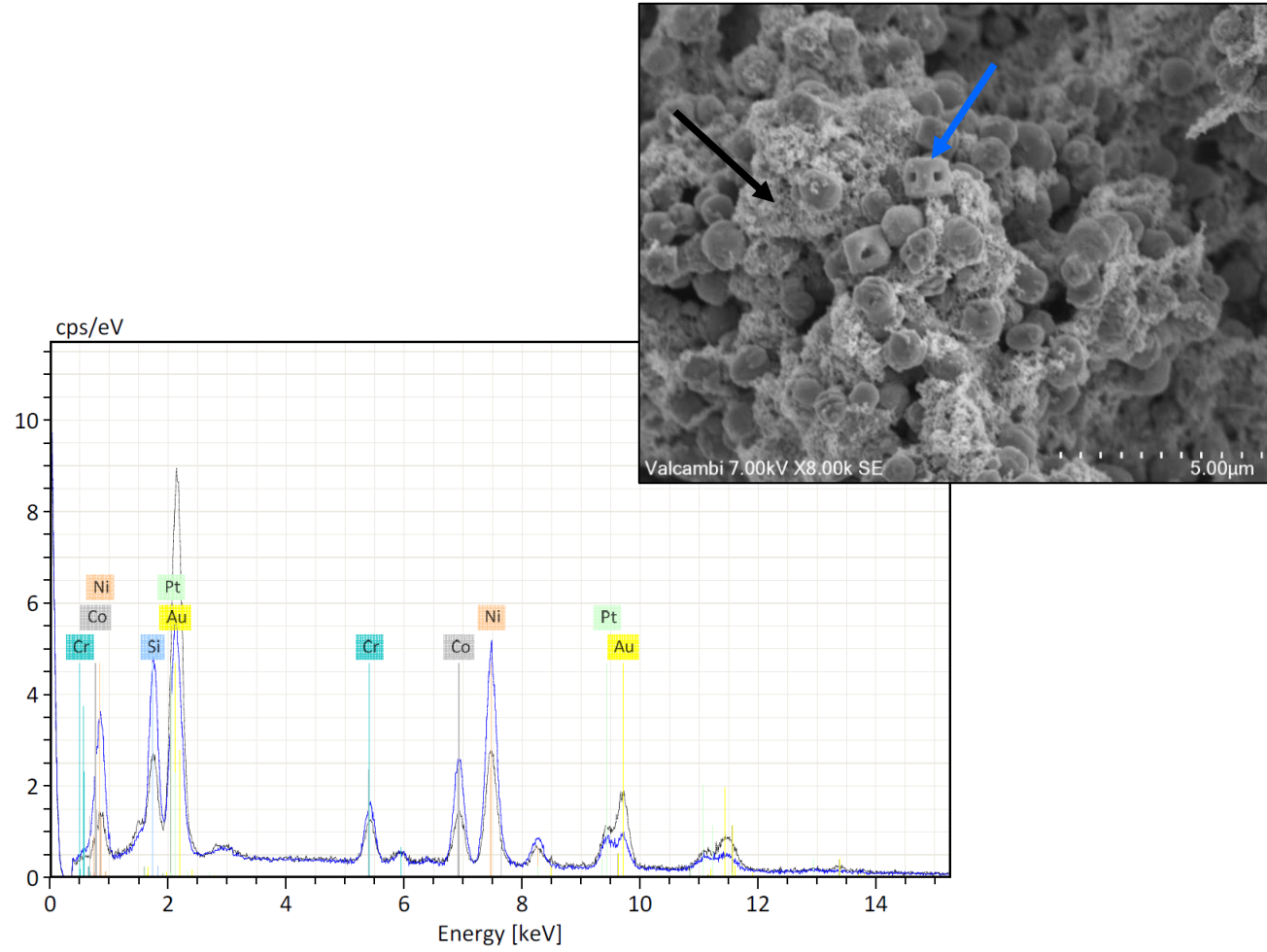
24 replicates



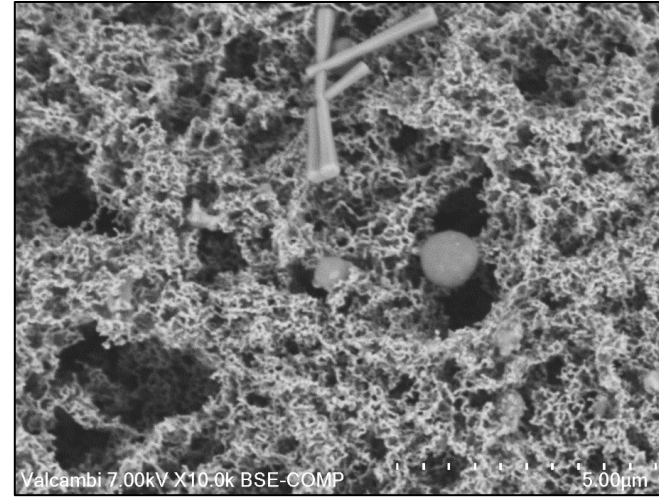
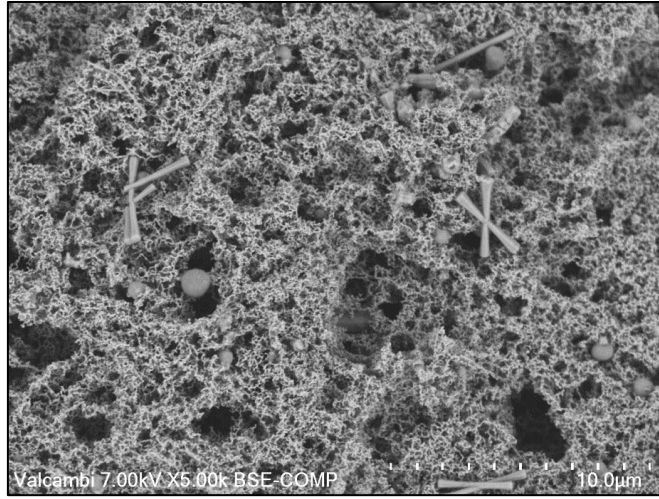
Sample A - morphology



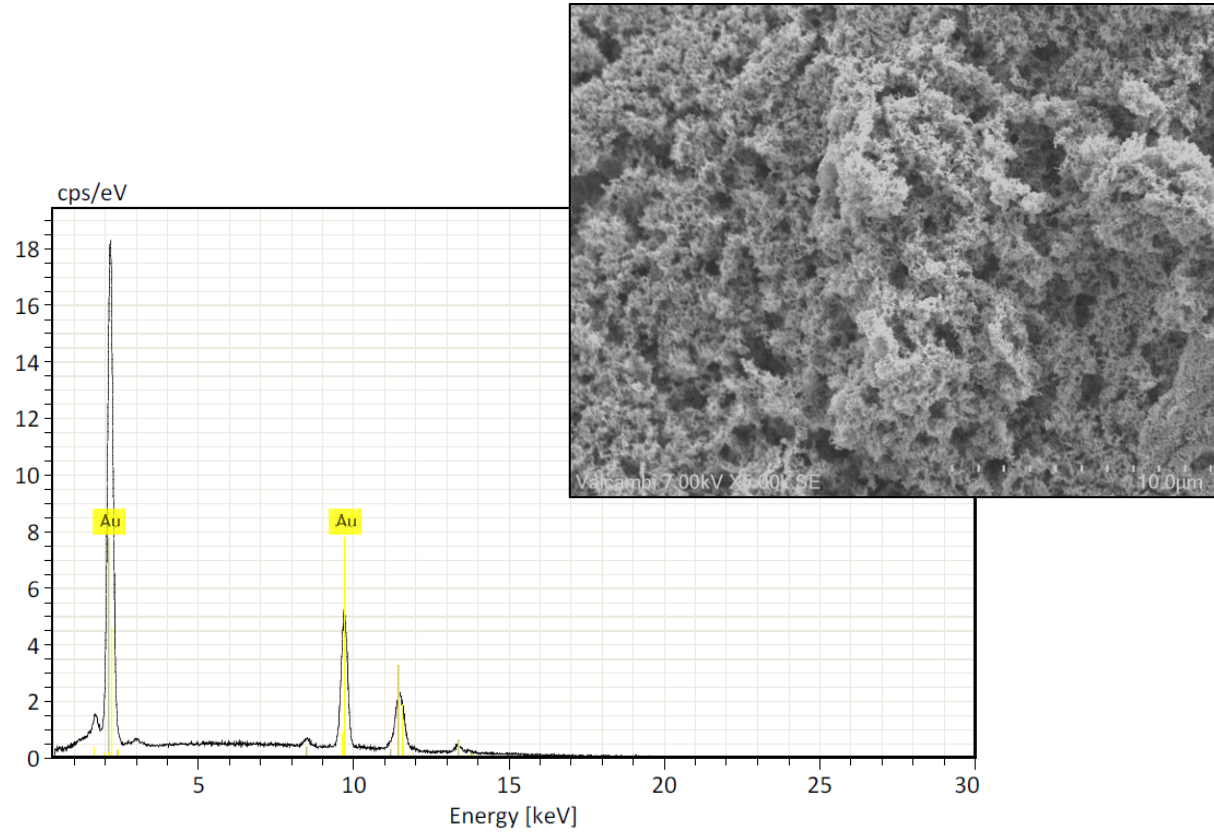
Sample A – EDX analysis



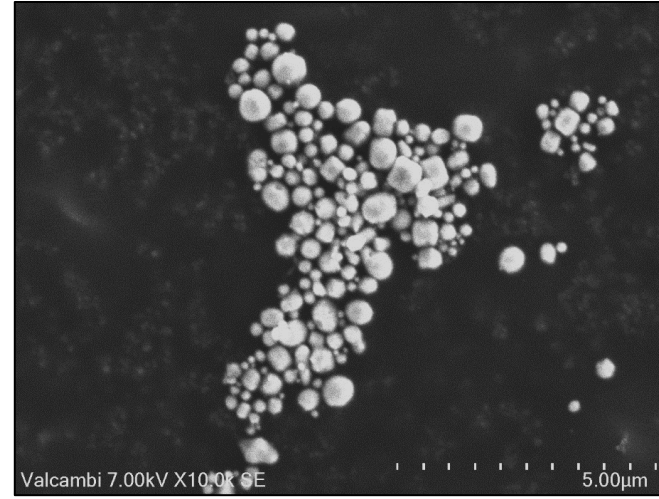
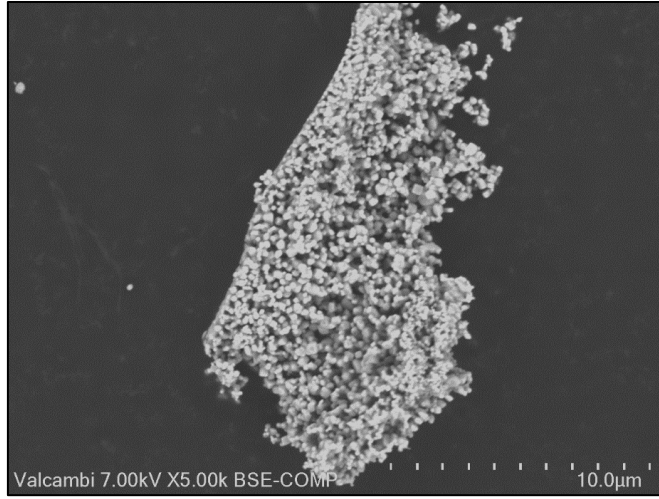
Sample B - morphology



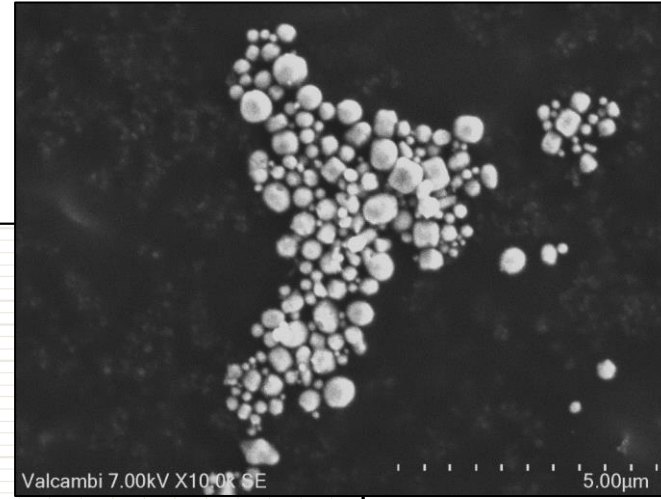
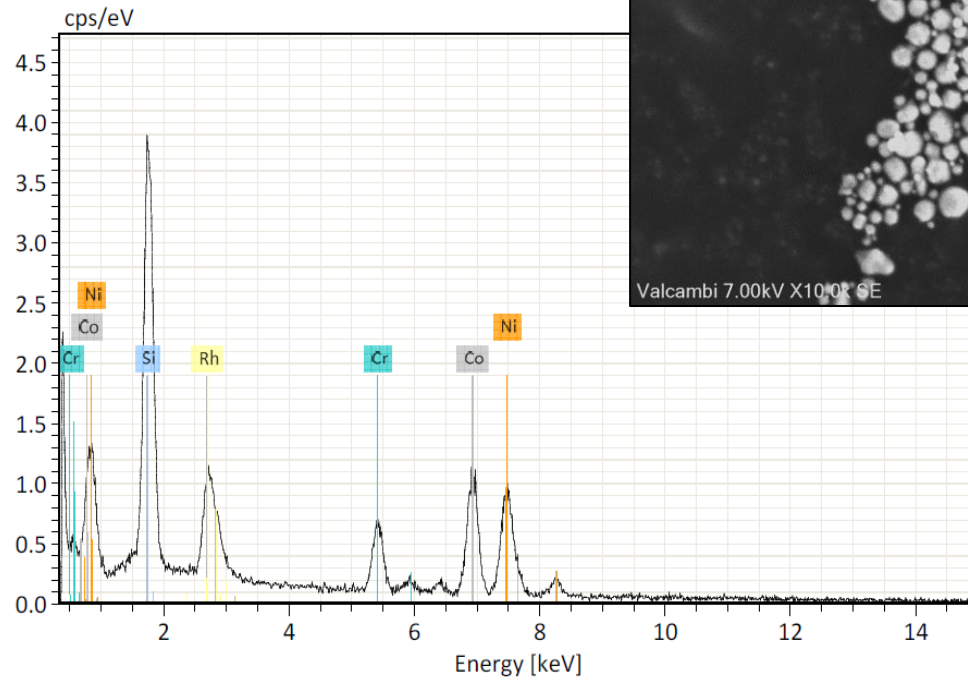
Sample B – EDX analysis



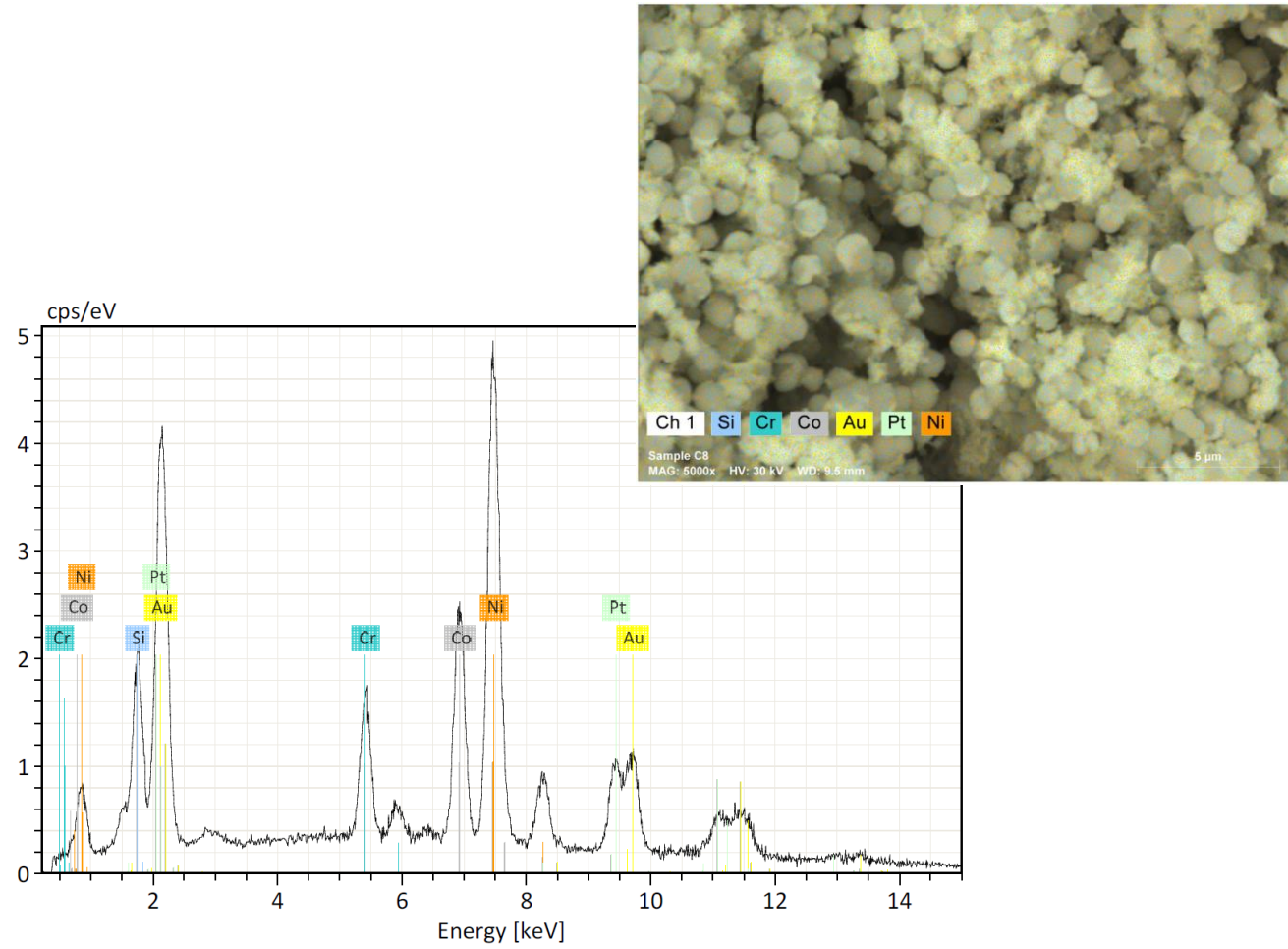
Sample C - morphology



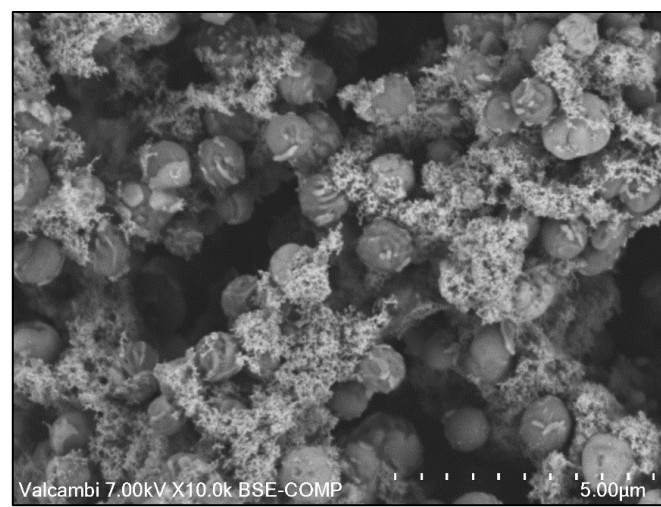
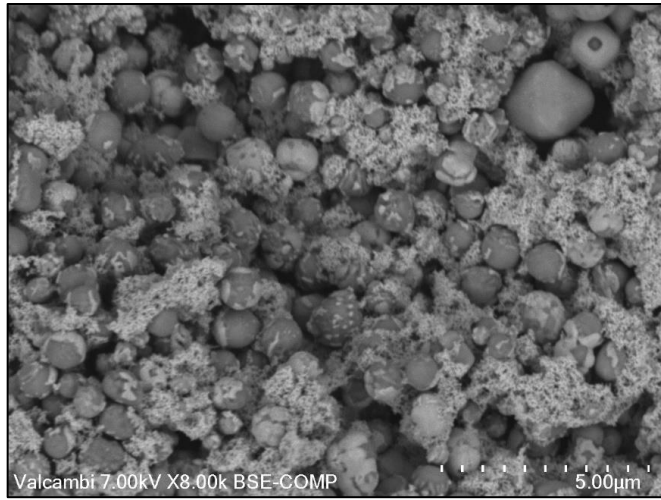
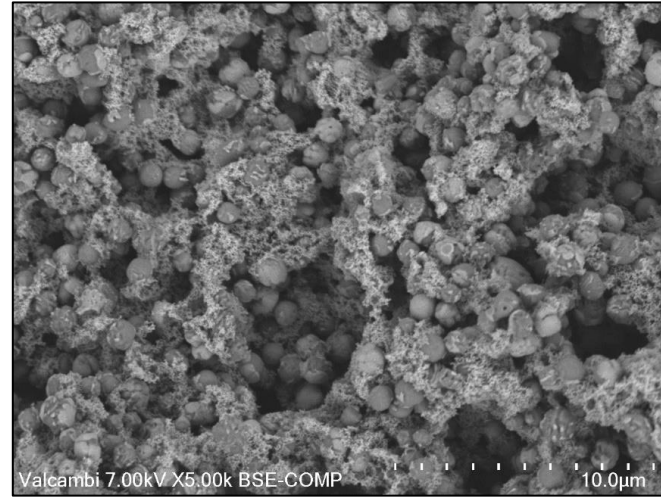
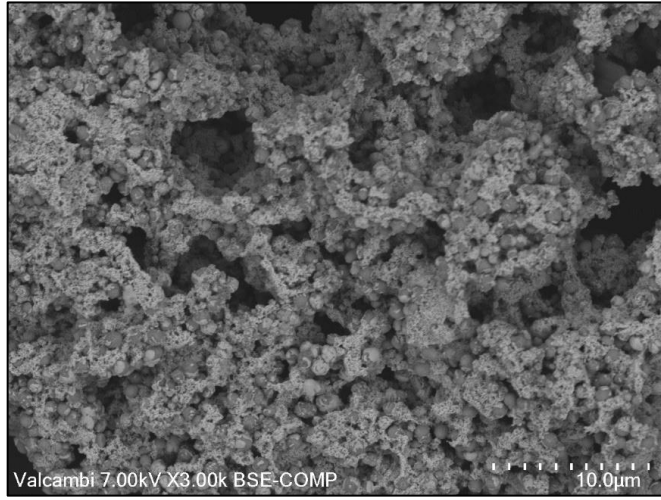
Sample C – EDX analysis



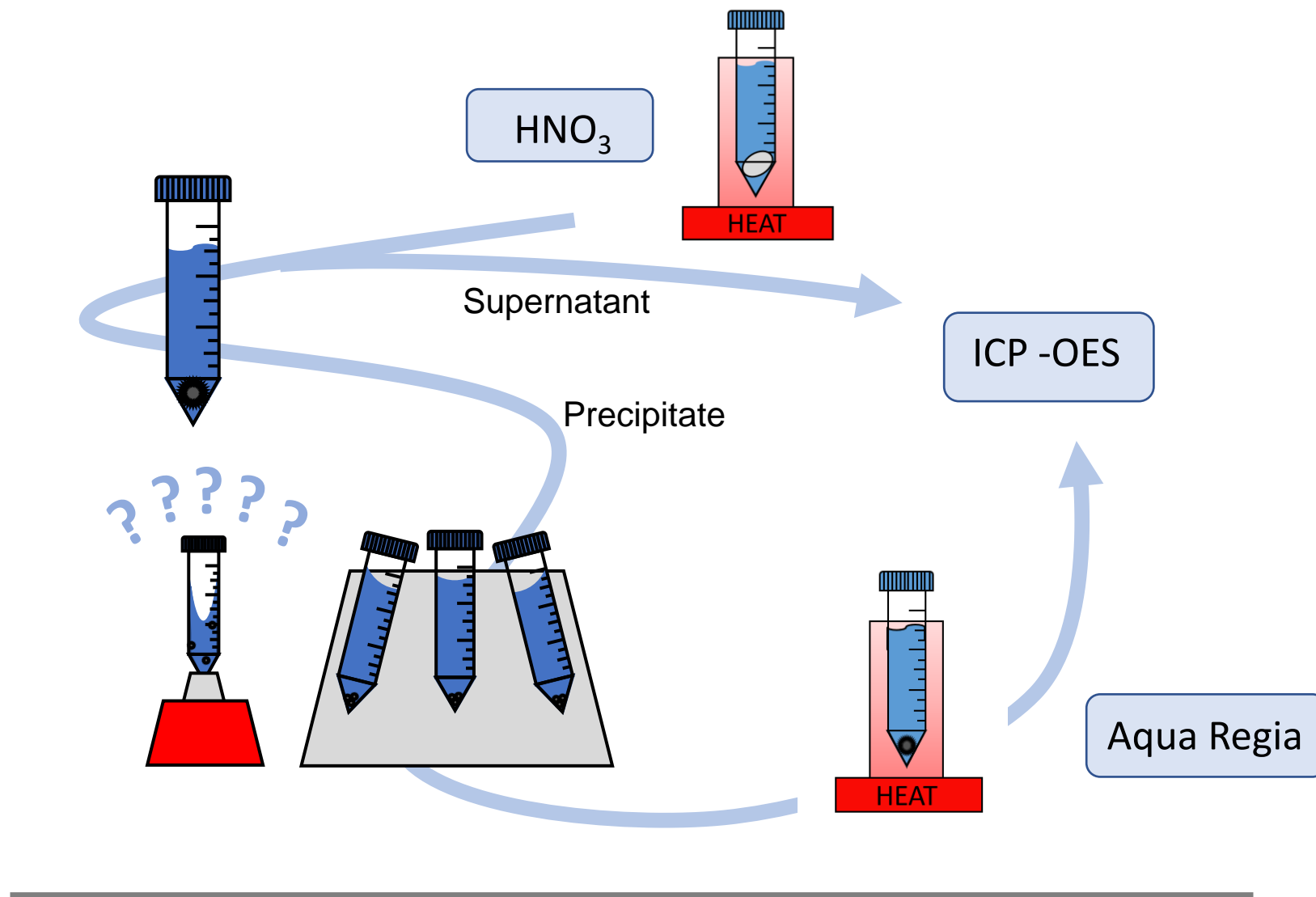
Sample A – mapping & pics



Sample A – mapping & pics



Question



Conclusions

- Vortex is useful for samples with a high gold content, combined with other impurities
 - The size of the residue decreases more than sixfold
 - This allows a greater surface exposed during dissolution in aqua regia
 - Improved dissolution gives more reliable and consistent results
-



Disclaimer

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