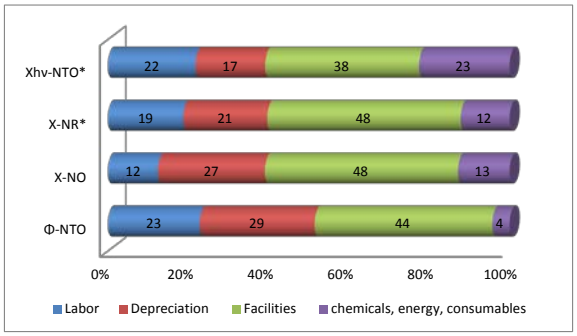
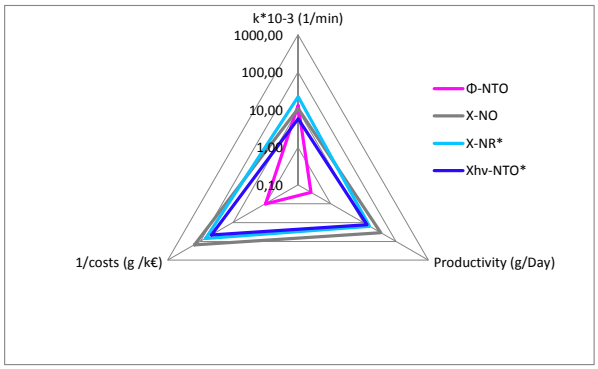
Benchmarking of performance, costs and productivity

Best Sample	$t_{1/2}$ (min)	Production time (h/g)	costs (€/g)
Φ-NTO	53	47,00	986,21 €
X-NO	64	0,52	6,61 €
X-NR*	31	1,15	14,62 €
Xhv-NTO*	119	2,08	21,73 €

Benchmarking of performance, costs and productivity

Best Sample	$k*10^{-3}$ (1/min)	Productivity (g/Day)	1/costs (g /k€)	hourly production rate (mg/h)
Φ-NTO	13,08	0,25	1,01	21
X-NO	10,83	34,33	151,20	1925
X-NR*	22,36	15,50	68,41	873
Xhv-NTO*	5,82	13,10	46,02	481





For one Batch	Labor	Depreciation	Facilities	chemicals, energy, consumables
Φ-NTO	450,84 €	564,36 €	872,73 €	84,48 €
X-NO	84,94 €	181,37 €	327,27 €	87,63 €
X-NR*	84,94 €	94,89 €	218,18 €	55,12 €
Xhv-NTO*	124,14 €	98,76 €	218,18 €	128,29 €

For one Batch	Labor	Depreciation	Facilities	chemicals, energy, consumables
Φ-NTO	23	29	44	4
X-NO	12	27	48	13
X-NR*	19	21	48	12
Xhv-NTO*	22	17	38	23

For one gram	Labor	Depreciation	Facilities	chemicals, energy, consumable	Total
Φ-NTO	225,42 €	282,18 €	436,36 €	42,24 €	986,21 €
X-NO	0,82 €	1,76 €	3,18 €	0,85 €	6,61 €
X-NR*	2,74 €	3,06 €	7,04 €	1,78 €	14,62 €
Xhv-NTO*	4,74 €	3,77 €	8,33 €	4,90 €	21,73 €

The following table is a tool developped to assess the production costs of one production batch of nanoparticles, and then infer the production costs for 1g of dried nanoparticles

The time duration to produce one batch is an important parameter since it will defined the manpower costs, as well as equipment depreciation. We assume **5 years for the depreciation of the investments (standard value)**

In the following table, the time duration is divided in two parts: (i) the working time of a technicien (Manpower) and (ii) the equipment operating times. The manpower is used to compute the salary cost, the equipment operating times is used to compute the depreciation of the investments (equipments) and the electricity costs. Moreover, an immobilisation of the equipment is used to compute the rental cost of the facilities

Rental of facilities: 30 m^2 of experimental room including a fume hood, an office of 10 m^2, the rental expenses (processing of the chemical waste, fluids consumption, cleaning and security, air conditionning).

Hourly costs of a qualified technicians including taxes [€/hours]	26,14 €	Wage bill (Annualy) including taxes for a French qualified technician, median value [€]	42000	Legal working time per years [hours]	1607	**For the sake of comparing the different methods, we will use the same hourly costs for all the synthesis (i.e. french values)**	
Electricity cost (France, VAT excluded) [€ / kWh]	0,12 €						
Usefull Machine time on 5 years (for depreciation) [hours]	8800	Depreciation period [year]	5	Working weeks in a year	44	Machine time per week [Hours]	40
Rental cost per working day [€/day]	109,09 €	Facilities rental [€/years]	24000	Working days in a year = Working Weeks x 5 Days	220		

Pulsed Laser Ablation In Liquids

			Comments		
Productivity, i.e. weight in grams of dried powder produced in one batch	**2**	[g/batch]			
Volume of purified water (18MΩ) used to produce one batch	**20,4**	[L]	18MΩ water produced with a purification units	Purification cost [€/L]	0,308813788
Immobilisation of the equipments for one batch	**8**	[Days]	For PLAL synthesis, the critical step is the ablation step. Preparation and purification can be performed in parallel on an other batch.		
Product costs for one batch (chemicals…)	**10,64 €**	[€] VAT excluded	CeO2 powders 99,99% (3 targets, 3 g/target, 591€/500g)		
Consumable (chemicals excluded)	**25,00 €**		Fluidic system (3D printing + tubes) ~ 25€		

Time duration: Manpower (time spent by an researcher/technician) and machine time are separated. As an exemple, for PLAL, the target preparation involves 1H of work for the pellet preparation, even if the time duration of the annealing is 24H	**Manpower [Hours]**	**Equipment operating times [Hours]**	**Power consumption of the machines [W]**	**Electricity costs per batch [€] VAT excluded**	**Investment Cost of the equipments [€] VAT excluded**	**Equipments depreciation for one batch [€] VAT excluded**	**Comments**
Synthesis preparation	1	24	4500	13,05 €	16000	43,64 €	Target preparation, Oven (4500 W, 16000€)
Synthesis (main process involving "expensive" setup or apparatus)	12	68	3000	24,65 €	65000	502,27 €	Ablation in the fluid system (laser 50000€, computer, driving system+optics+peristaltic pump + laser security 15000€)
Post-treatment and purification	4	16	1880	3,63 €	8900	16,18 €	Rotovap (Bath+motor 1200W, Pump 30W, Chiller 650W)
Post-treatment and purification	0,25	10	1000	1,21 €	2000	2,27 €	drying (Oven 1000W), one night
Labor:	**450,84 €**		**Electricity:**	**42,54 €** VAT excluded	**Depreciation:**	**564,36 €** VAT excluded	

Total chemicals, energy, consumables	**84,48 €**
Rental cost of the facilities	**872,73 €**

Production cost per gram, VAT excluded	**986,21 €**	**$1 084,83**	**Not included: press for target preparation (Marginal), R&D, quality control**

Post-annealing		0	4	4500	2,18 €	16000	7,27 €
Production cost per gram, including post-annealing VAT excluded	**990,93 €**	**$1 090,02**					

Info Water purification (18MΩ)		Price, one Kit	Volume produced, one kit [L]	Volume used for on batch	Costs
PREtreatment SMART2PURE Kit		**293,91**	**1800**	20,4	3,33098
ULTRA PURE Water KIT		**372,69**	**4000**	20,4	1,900719
	flow rate (L/H)	volume used for one batch [L]	Production time [H]	Smart2Pure System	Depreciation
Smart2Pure system (6L/H)	**6**	20,4	3,4	**2764,5**	1,068102273
			Total cost water		6,299801273

The following table is a tool developped to assess the production costs of one production batch of nanoparticles, and then infer the production costs for 1g of dried nanoparticles

The time duration to produce one batch is an important parameter since it will defined the manpower costs, as well as equipment depreciation. We assume **5 years for the depreciation of the investments (standard value)**

In the following table, the time duration is divided in two parts: (i) the working time of a technicien (Manpower) and (ii) the equipment operating times. The manpower is used to compute the salary cost, the equipment operating times is used to compute the depreciation of the investments (equipments) and the electricity costs. Moreover, an immobilisation of the equipment is used to compute the rental cost of the facilities

Rental of facilities: 30 m^2 of experimental room including a fume hood, an office of 10 m^2, the rental expenses (processing of the chemical waste, fluids consumption, cleaning and security, air conditionning).

Hourly costs of a qualified technicians including taxes [€/hours]	26,14 €	Wage bill (Annualy) including taxes for a French qualified technician, median value [€]	42000	Legal working time per years [hours]	1607	**For the sake of comparing the different methods, we will use the same hourly costs for all the synthesis (i.e. french values)**	
Electricity cost (France, VAT excluded) [€ / kWh]	0,12 €						
Usefull Machine time on 5 years (for depreciation) [hours]	8800	Deprecisation period [year]	5	Working weeks in a year	44	Machine time per week [Hours]	40
Rental cost per working day [€/day]	109,09 €	Facilities rental [€/years]	24000	Working days in a year = Working Weeks x 5 Days	220		

Photochemistry

			Comments		
Productivity, i.e. weight in grams of dried powder produced in one batch	**26,2**	[g/batch]			
Volume of purified water (18MΩ) used to produce one batch	**80**	[L]	18MΩ water produced with a purification units	Purification cost [€/L]	0,308813788
Immobilisation of the equipments for one batch	**2**	[Days]	Pilot plant synthesis and whashing time of the pilot plant		
Product costs for one batch (chemicals…)	**90,27 €**	[€] VAT excluded	173.68 g of cerium nitrate hexahydrate + 504.48 g of ammonium formate		
Consumable (chemicals excluded)	**1,20 €**				

Time duration: Manpower (time spent by an researcher/technician) and machine time are separated. As an exemple, for PLAL, the target preparation involves 1H of work for the pellet preparation, even if the time duration of the annealing is 24H	**Manpower [Hours]**	**Equipment operating times [Hours]**	**Power consumption of the machines [W]**	**Electricity costs per batch [€] VAT excluded**	**Investment Cost of the equipments [€] VAT excluded**	**Equipments depreciation for one batch [€] VAT excluded**	**Comments**
Synthesis preparation	0,5	0,5	40	0,00 €	248,5	0,01 €	
Synthesis (main process involving "expensive" setup or apparatus)	2	26	2732	8,58 €	30000	88,64 €	Photochemical plant purchase and installation cost
Post-treatment and purification	2	2	600	0,15 €	2464	0,56 €	
Post-treatment and purification	0,25	10	1000	1,21 €	2000	2,27 €	drying (Oven 1000W), one night
Labor:	**124,14 €**		**Electricity:**	**9,94 €**	**Depreciation:**	**91,48 €**	
				VAT excluded		**VAT excluded**	
Total chemicals, energy, consumables	**126,12 €**						
Rental cost of the facilities	**218,18 €**						

Production cost per gram, VAT excluded	**21,37 €**	**$23,51**	**Not included: press for target preparation (Marginal), R&D, quality control …**

Post-annealing		0	4	4500	2,18 €	16000	7,27 €
Production cost per gram, including post-annealing VAT excluded	**21,73 €**	**$23,90**					

The following table is a tool developped to assess the production costs of one production batch of nanoparticles, and then infer the production costs for 1g of dried nanoparticles

The time duration to produce one batch is an important parameter since it will defined the manpower costs, as well as equipment depreciation. We assume **5 years for the depreciation of the investments (standard value)**

In the following table, the time duration is divided in two parts: (i) the working time of a technicien (Manpower) and (ii) the equipment operating times. The manpower is used to compute the salary cost, the equipment operating times is used to compute the depreciation of the investments (equipments) and the electricity costs. Moreover, an immobilisation of the equipment is used to compute the rental cost of the facilities

Rental of facilities: 30 m^2 of experimental room including a fume hood, an office of 10 m^2, the rental expenses (processing of the chemical waste, fluids consumption, cleaning and security, air conditionning).

Hourly costs of a qualified technicians including taxes [€/hours]	26,14 €	Wage bill (Annualy) including taxes for a French qualified technician, median value [€]	42000	Legal working time per years [hours]	1607	**For the sake of comparing the different methods, we will use the same hourly costs for all the synthesis (i.e. french values)**		
Electricity cost (France, VAT excluded) [€ / kWh]	0,12 €							
Usefull Machine time on 5 years (for depreciation) [hours]	8800	Deprecisation period [year]	5	Working weeks in a year	44	Machine time per week [Hours]	40	
Rental cost per working day [€/day]	109,09 €	Facilities rental [€/years]	24000	Working days in a year = Working Weeks x 5 Days	220			

Hydrotermal - nanorods

			Comments		
Productivity, i.e. weight in grams of dried powder produced in one batch	**31**	[g/batch]			
Volume of purified water (18MΩ) used to produce one batch	**7**	[L]		Purification cost [€/L]	0,308813788
Immobilisation of the equipments for one batch	**2**	[Days]	Autoclave: synthesis duration + warming/cooling time (cooling 12h@100°C)		
Product costs for one batch (chemicals…)	**46,20 €**	[€] VAT excluded	Ce(NO3)3.6H2O : 265€/1kg; NaOH: 286€/10kg		
Consumable (chemicals excluded)	**0,00 €**				

Time duration: Manpower (time spent by an researcher/technician) and machine time are separated. As an exemple, for PLAL, the target preparation involves 1H of work for the pellet preparation, even if the time duration of the annealing is 24H	**Manpower [Hours]**	**Equipment operating times [Hours]**	**Power consumption of the machines [W]**	**Electricity costs per batch [€] VAT excluded**	**Investment Cost of the equipments [€] VAT excluded**	**Equipments depreciation for one batch [€] VAT excluded**	**Comments**
Synthesis preparation	1	1	20	0,00 €	1070	0,12 €	Balance (520€); stirrer (20W, 550€)
Synthesis (main process involving "expensive" setup or apparatus)	0,5	7	3000	2,54 €	37499	29,83 €	Autoclave
cooling of the autoclave	0	12	0	0,00 €	37499	51,14 €	Autoclave
Post-treatment and purification	1,5	1,5	4600	0,83 €	25000	4,26 €	Washing / centrifugation
Post-treatment and purification	0,25	10	1000	1,21 €	2000	2,27 €	Drying
Labor:	**84,94 €**		**Electricity:**	**4,58 €** VAT excluded	**Depreciation:**	**87,62 €** VAT excluded	

Total chemicals, energy, consumables	**52,94 €**
Rental cost of the facilities	**218,18 €**

Production cost per gram, VAT excluded	**14,31 €**	**$15,74**	**Not included: press for target preparation (Marginal), R&D, quality control …**

Post-annealing		0	4	4500	2,18 €	16000	7,27 €
Production cost per gram, including post-annealing VAT excluded	**14,62 €**	**$16,08**					

The following table is a tool developped to assess the production costs of one production batch of nanoparticles, and then infer the production costs for 1g of dried nanoparticles

The time duration to produce one batch is an important parameter since it will defined the manpower costs, as well as equipment depreciation. We assume **5 years for the depreciation of the investments (standard value)**

In the following table, the time duration is divided in two parts: (i) the working time of a technicien (Manpower) and (ii) the equipment operating times. The manpower is used to compute the salary cost, the equipment operating times is used to compute the depreciation of the investments (equipments) and the electricity costs. Moreover, an immobilisation of the equipment is used to compute the rental cost of the facilities

Rental of facilities: 30 m^2 of experimental room including a fume hood, an office of 10 m^2, the rental expenses (processing of the chemical waste, fluids consumption, cleaning and security, air conditionning).

Hourly costs of a qualified technicians including taxes [€/hours]	26,14 €	Wage bill (Annualy) including taxes for a French qualified technician, median value [€]	42000	Legal working time per years [hours]	1607	**For the sake of comparing the different methods, we will use the same hourly costs for all the synthesis (i.e. french values)**		
Electricity cost (France, VAT excluded) [€ / kWh]	0,12 €							
Usefull Machine time on 5 years (for depreciation) [hours]	8800	Depreciation period [year]	5	Working weeks in a year	44	Machine time per week [Hours]	40	
Rental cost per working day [€/day]	109,09 €	Facilities rental [€/years]	24000	Working days in a year = Working Weeks x 5 Days	220			

Hydrotermal - nano-octahedra

			Comments
Productivity, i.e. weight in grams of dried powder produced in one batch	**103**	[g/batch]	
Volume of purified water (18MΩ) used to produce one batch	**7**	[L]	
Immobilisation of the equipments for one batch	**3**	[Days]	Autoclave: synthesis duration + warming/cooling time (cooling 15h@180°C)
Product costs for one batch (chemicals…)	**74,00 €**	[€] VAT excluded	Ce(NO3)3.6H2O : 265€/1kg; NH4OH : 33,9€/2,5L
Consumable (chemicals excluded)	**0,00 €**		

Purification cost [€/L]: 0,308813788

Time duration: Manpower (time spent by an researcher/technician) and machine time are separated. As an exemple, for PLAL, the target preparation involves 1H of work for the pellet preparation, even if the time duration of the annealing is 24H	**Manpower [Hours]**	**Equipment operating times [Hours]**	**Power consumption of the machines [W]**	**Electricity costs per batch [€] VAT excluded**	**Investment Cost of the equipments [€] VAT excluded**	**Equipments depreciation for one batch [€] VAT excluded**	**Comments**
Synthesis preparation	1	1	20	0,00 €	1070	0,12 €	Balance (520€); stirrer (20W, 550€)
Synthesis (main process involving "expensive" setup or apparatus)	0,5	26	3000	9,43 €	37499	110,79 €	Autoclave
cooling of the autoclave	0	15	0	0,00 €	37499	63,92 €	Autoclave
Post-treatment and purification	1,5	1,5	4600	0,83 €	25000	4,26 €	Washing / centrifugation
Post-treatment and purification	0,25	10	1000	1,21 €	2000	2,27 €	Drying
Labor:	**84,94 €**		**Electricity:**	**11,47 €**	**Depreciation:**	**181,37 €**	
				VAT excluded		**VAT excluded**	

Total chemicals, energy, consumables	**87,63 €**
Rental cost of the facilities	**327,27 €**

Production cost per gram, VAT excluded	**6,61 €**	**$7,28**	**Not included: press for target preparation (Marginal), R&D, quality control …**

Post-annealing	0	4	4500	2,18 €	16000	7,27 €	
Production cost per gram, including post-annealing VAT excluded	**6,71 €**	**$7,38**					