

PrometheanParticles



Formulating solutions with nanomaterials

DISPERSIONS PORTFOLIO 2017



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PrometheanParticles



Formulating solutions with nanomaterials

Promethean Particles design, develop and manufacture inorganic nanoparticle dispersions to our customer's specifications.

We cover many industry needs such as printed electronics (enabling flexible circuitry, 3D printing etc.), nanocomposites, catalysts, MOFs, healthcare etc. In addition, we work with customers on feasibility studies to tailor a custom made solution for specific requirements.

We use continuous hydrothermal synthesis to make the optimum product for each application and back this up with large scale manufacturing capability, now up to 1000 tons a year in our new premises.

Promethean Particles has the world's LARGEST continuous multi-material nanoparticle manufacturing plant.

The list of dispersions below is non-exhaustive, please get in touch for any specific requirement.



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Formulating solutions with nanomaterials

1. Metals

- a. Copper
- b. Silver

2. Metal oxides

- a. Titanium dioxide
- b. Mixed metal oxides
- c. Indium
- d. Zirconium
- e. Cerium
- f. Silicon dioxide / Silica
- g. Barium titanate
- h. Iron oxide (Fe_2O_3 , Fe_3O_4)
- i. Zinc oxide

3. MOFs

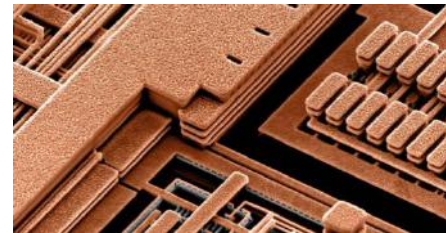
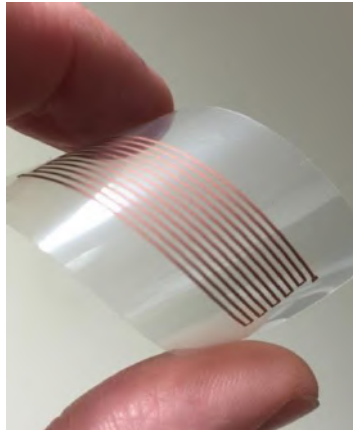
- a. ZIF-8
- b. MIL-53(Al)
- c. HKUST-1

4. Phosphates

5. Precious metals

- a. Gold
- b. Platinum
- c. Palladium

6. Feasibility studies

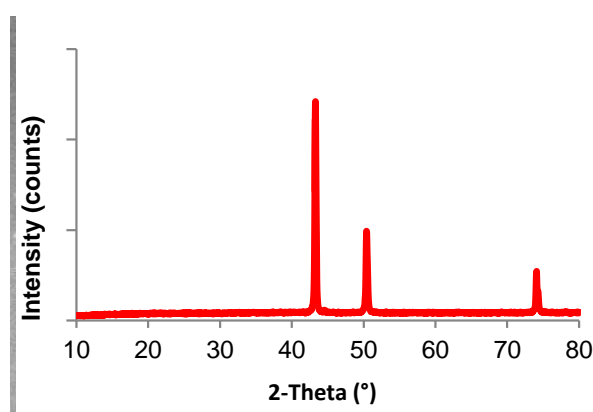


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1. Metals

a. Copper



The image above an x-ray diffraction pattern showing the copper structure without any oxide impurity.

Product Name:	Copper nano-dispersion
CAS #:	7440-50-8
Composition:	Copper with oxidative stabiliser
Preparation:	Nano-dispersion in isopropanol (other media are available)
Appearance:	dark red
Particle size:	< 100nm
Morphology:	Spherical particles
Dispersion loading:	50 – 70 wt. %
Solvent choice:	Material can be readily dispersed into a range of solvents, please contact for more information.

Applications: Printed electronics, conductive inks, antimicrobial applications.

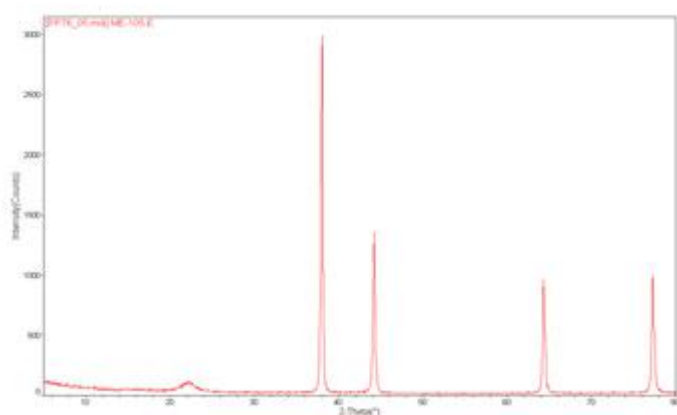
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1. Metals

b. Silver nano-dispersion



Product Name:	Silver nano-dispersion
CAS #:	7440-22-4
Composition:	Silver particles in water
Preparation:	Nano-dispersion in water (other media are available)
Appearance:	Grey dispersion
Morphology:	Spherical particles
Dispersion loading:	50 – 60 wt. %
Solvent choice:	Material can be readily dispersed into a range of solvents, please contact for more information.

Applications: Printed electronics, conductive inks, antimicrobial applications.

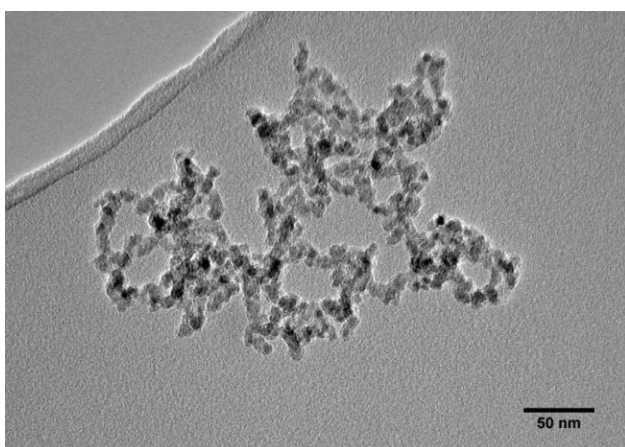
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Formulating solutions with nanomaterials

2. Metal oxides

a. Titanium (IV) Oxide Nano-Dispersion



Product Name: Titanium(IV) oxide nano-dispersion

Synonyms: Titanium dioxide, titania

Composition: TiO_2

CAS #: 13463-67-7

Preparation: Aqueous slurry

Appearance: White suspension

Crystal structure: Anatase

Particle size: 5 - 10 nm (by TEM)

Morphology: Spherical particles

Dispersion loading: Up to 10 wt %

Dispersion pH: 1-2

Applications: Cosmetics, solar cells, medical applications, paints and pigments.

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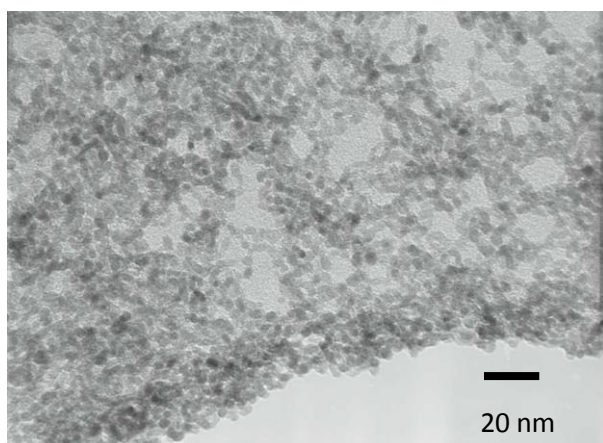
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Formulating solutions with nanomaterials

2. Metal oxides

b. Zirconium(IV) oxide nano-dispersion



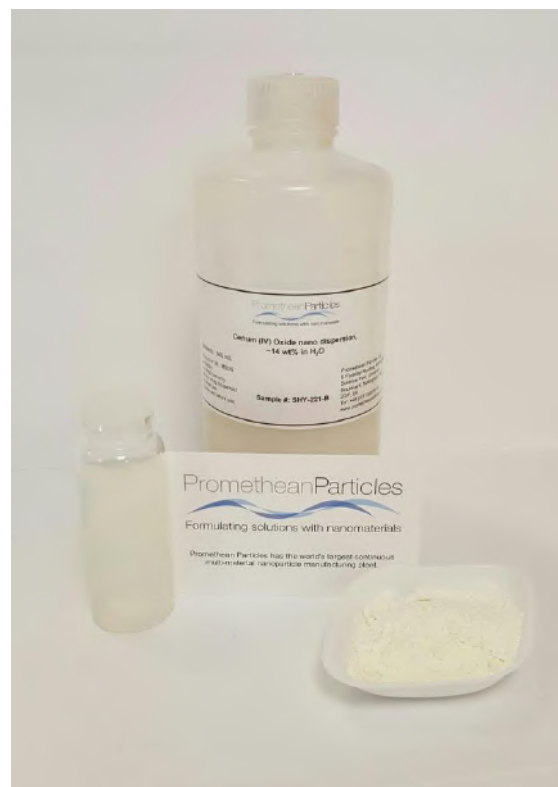
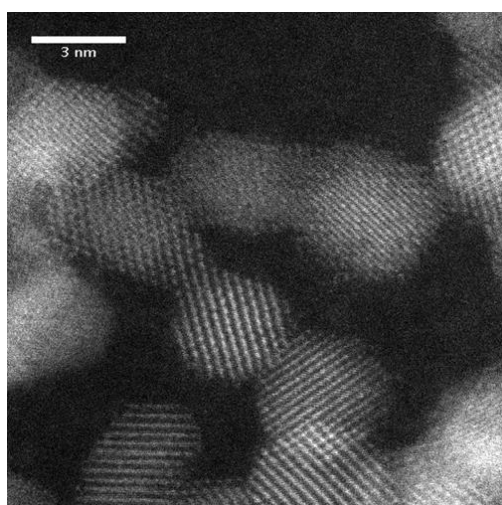
Product Name:	Zirconium(IV) oxide nano-dispersion
Synonyms:	Zirconium dioxide, zirconia
Composition:	ZrO ₂
CAS #:	1314-23-4
Molecular weight:	123.22
Preparation:	Aqueous nano-dispersion
Appearance:	Clear/hazy suspension (concentration dependent)
Particle size:	3-5 nm (by TEM)
Morphology:	Spherical particles
Dispersion loading:	up to 10 wt %
Dispersion pH:	2-4
Applications:	Optical polymer modifier, oxygen sensors, solid oxide fuel cells, bioceramics, implant devices, thermal barrier coatings.

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2. Metal oxides

c. Cerium(IV) oxide nano-dispersion



Product Name:	Cerium(IV) oxide nano-dispersion
Composition:	CeO ₂
CAS #:	1306-38-3
Preparation:	Aqueous slurry
Appearance:	Pale yellow/white suspension
Particle size:	5 - 10 nm (by TEM) 40-50 nm (Z-average, DLS, uncoated particles)
Morphology:	Spherical particles
Dispersion loading:	Up to 10 wt %
Dispersion pH:	2-4

Applications: Fuel additive, fuel cells, catalysis.

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2. Metal oxides

d. Silicon dioxide



Product Name: Silicon(IV) oxide nano-dispersion

Synonyms: Silica

Composition: SiO₂

CAS #: 7631-86-9

Preparation: Aqueous slurry

Appearance: Clear/hazy suspension

Particle size: <50 nm

Morphology: Spherical particles

Dispersion loading: Up to 10 wt %

Applications: Catalysis, water treatment, ceramics

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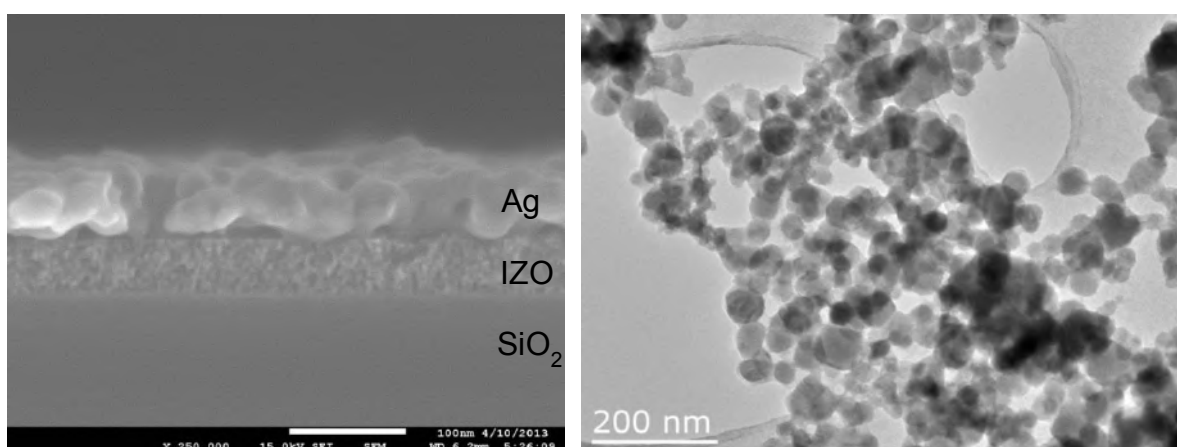


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2. Metal oxides

e. Indium Zinc Oxide Nano-Dispersion

(Upon raw material availability from supplier)



Product Name:	Indium zinc oxide
Synonyms:	Zinc-doped indium oxide
Composition:	$\text{In}_x\text{Zn}_{1-x}\text{O}_y$ (typical In:Zn ratio 14:3)
Preparation:	Alcohol-based nano-dispersion, polyol stabilised
Appearance:	Clear/hazy pale yellow suspension (concentration dependent)
Particle size:	<50 nm (by TEM)
Morphology:	Spherical particles
Dispersion loading:	up to 4 wt %

Applications: Semiconductor pre-ink for thin-film applications, inkjet printable

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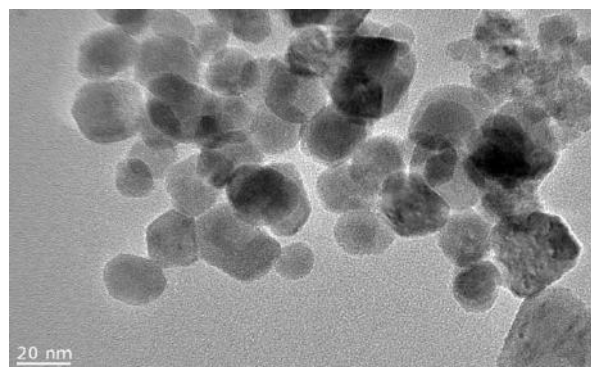
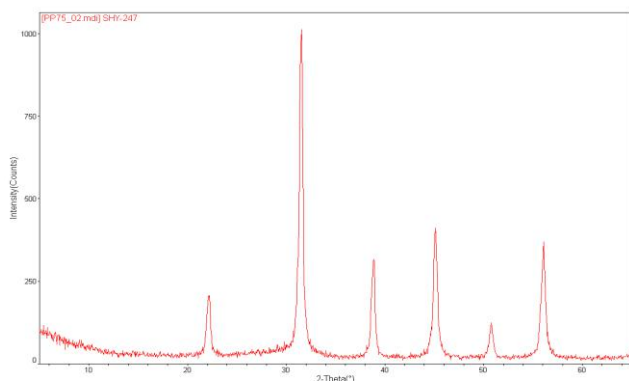


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2. Metal oxides

f. Barium Titanate Nano-dispersion

(material still under development)



The images above show a transmission electron micrograph of barium titanate particles and an x-ray diffraction pattern showing the BaTiO₃ structure.

Product Name:	Barium titanate nano-dispersion
CAS #:	7440-50-8
Composition:	BaTiO ₃
Preparation:	Nano-dispersion in water (other dispersion media are available)
Appearance:	White dispersion
Morphology:	Spherical particles
Dispersion loading:	15 – 25 wt. %

Applications: Dielectric material for thin-film applications (printed electronics)

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Formulating solutions with nanomaterials

2. Metal oxides

g. Iron oxides

Product Name: Iron(III) Oxide
Synonyms: Hematite
Composition: Fe_2O_3
CAS #: 1309-37-1
Preparation: Aqueous slurry
Appearance: Red-brown suspension
Morphology: Spheres or rods
Dispersion loading: Up to 5 wt %



Applications: Cosmetics, coatings, paints and pigments, healthcare.

Product Name: Iron(II, III) Oxide
Synonyms: Magnetite
Composition: Fe_3O_4
CAS #: 1317-61-9
Preparation: Aqueous slurry
Appearance: Black suspension
Morphology: Spherical particles
Dispersion loading: Up to 10 wt %



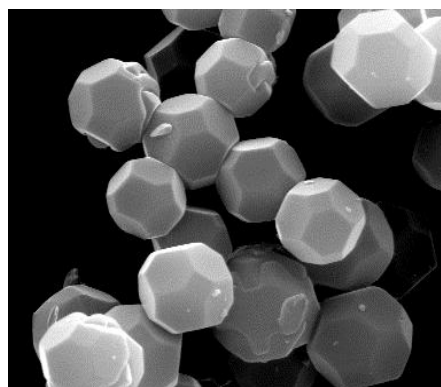
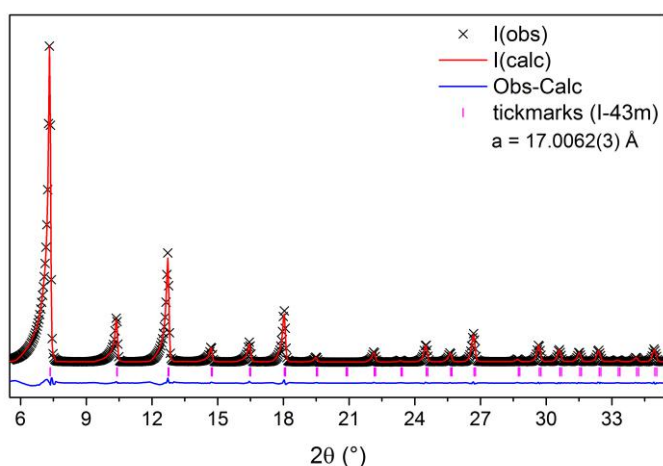
Applications: Superparamagnetic particles, medical imaging, pigments, healthcare.

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3. Metal-Organic Frameworks (MOFs)

a. ZIF-8



Product Name:	ZIF-8
Synonyms:	2-Methylimidazole zinc salt.
Composition:	$C_8H_{10}N_4Zn$
Preparation:	Powder
Appearance:	White powder
Surface area:	~2000 m ² /g (BET)
Applications:	Gas storage (e.g. H₂, CO₂), sensors, catalysis, gas/liquid separations

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Formulating solutions with nanomaterials

4. Metal-Organic Frameworks (MOFs)

b. MIL-53(Al)



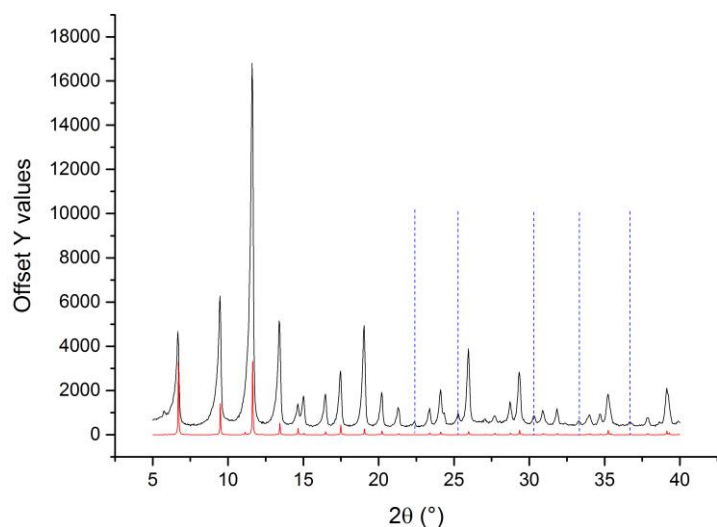
Product Name:	MIL-53(Al)
Synonyms:	Aluminum terephthalate.
Composition:	$C_8H_5AlO_5$
Preparation:	Powder
Appearance:	White powder
Surface area:	$\sim 1100 \text{ m}^2/\text{g}$ (BET)
Applications:	Gas storage (e.g. H_2, CO_2), sensors, catalysis, gas/liquid separations

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Formulating solutions with nanomaterials

4. Metal-Organic Frameworks (MOFs)

c. HKUST-1



Product Name: HKUST-1
Synonyms: Copper benzene-1,3,5-tricarboxylate, Cu-BTC, Copper trimesate
Composition: $C_{18}H_6Cu_3O_{12}$
Preparation: Powder
Appearance: Blue powder
Surface area: $\sim 2000 \text{ m}^2/\text{g}$ (BET)

Applications: Gas storage (e.g. H_2 , CO_2), sensors, catalysis, gas/liquid separations

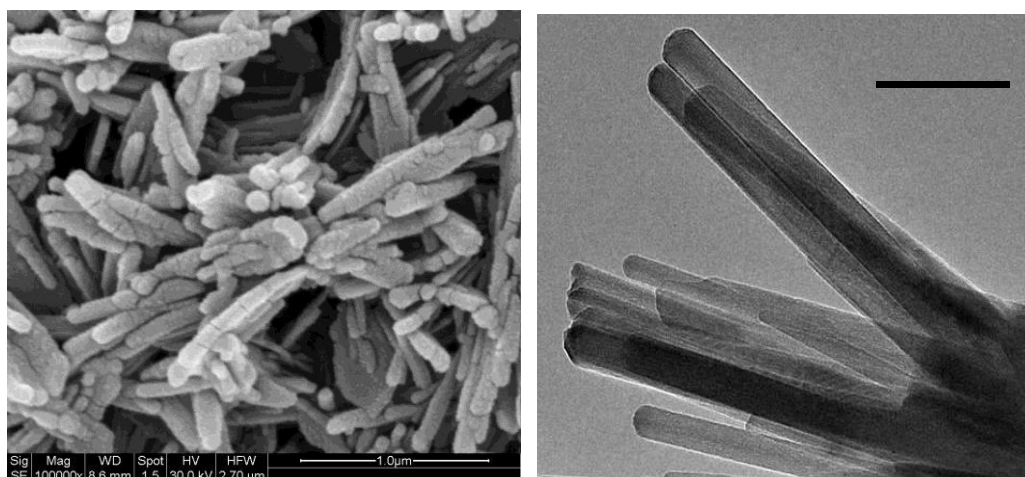
We are able to offer a large variety of other MOFs such as Ni-74, CPO-27 and many others. Other metal-ligand combinations are also available. Please contact us for any specific requirement and we will be happy review your requirements.

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4. Phosphates

a. Hydroxyapatite, rod morphology



Product Name:	Hydroxyapatite, rod morphology
Synonyms:	Calcium hydroxyphosphate, calcium phosphate tribasic, HA, HAp, hydroxylapatite
Composition:	$\text{Ca}_5(\text{PO}_4)_3\text{OH}$
CAS #:	12167-74-7
Molecular weight:	502.31
Preparation:	Aqueous slurry
Appearance:	White suspension
Particle size:	30-50 nm diameter (by TEM)
Morphology:	Rod
Dispersion loading:	up to 15 wt %
Dispersion pH:	9-10

Applications: Bioceramic coatings, bone fillers, prosthetics, dental products

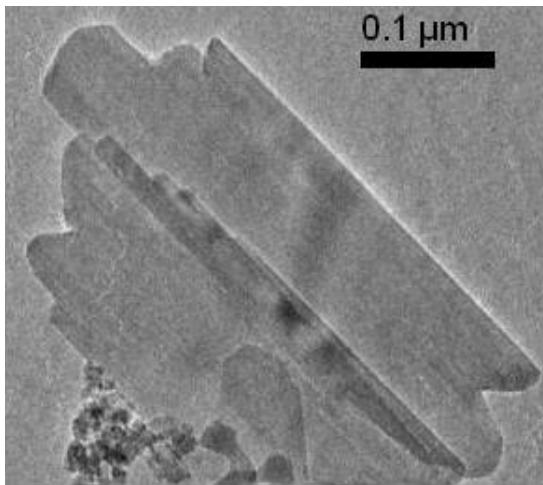
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Formulating solutions with nanomaterials

4. Phosphates

b. Hydroxyapatite, sheets



Product Name:	Hydroxyapatite, sheets
Synonyms:	Calcium hydroxyphosphate, calcium phosphate tribasic, HAp, hydroxylapatite
Composition:	$\text{Ca}_5(\text{PO}_4)_3\text{OH}$
CAS #:	12167-74-7
Molecular weight:	502.31
Preparation:	Aqueous slurry
Appearance:	Off-white suspension
Particle size:	0.5 - 1 µm
Morphology:	Sheets
Dispersion loading:	Up to 10 wt %
Dispersion pH:	7-8

Applications: Bioceramic coatings, bone fillers, prosthetics, confectionery.

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5. Precious metals

a. Gold



Product Name:	Gold
Composition:	Au
CAS #:	7440-57-5
Molecular weight:	196.97
Preparation:	Aqueous dispersion
Appearance:	Various colours
Particle size:	10-50 nm diameter (by DLS)
Morphology:	Spherical
Dispersion loading:	up to 5 wt %

Applications: Catalysis, diagnostics

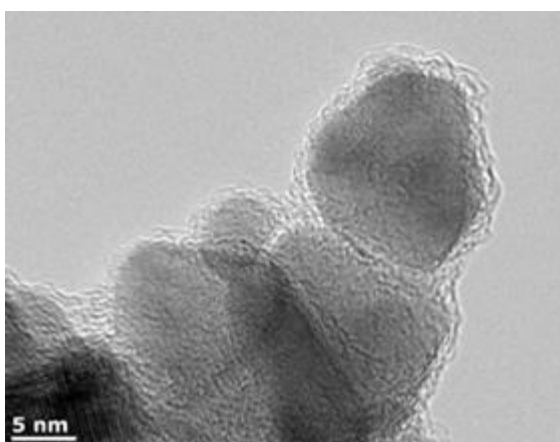
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6. Precious metals

b. Platinum



Product Name:	Platinum
Composition:	Pt
CAS #:	7440—06-4
Molecular weight:	195.08
Preparation:	Aqueous slurry
Appearance:	Black dispersion
Particle size:	20-40 nm diameter (by TEM)
Morphology:	Spherical
Dispersion loading:	up to 10 wt %

Applications: Catalysis, diagnostics

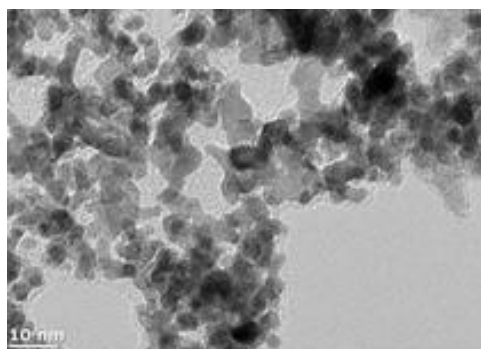
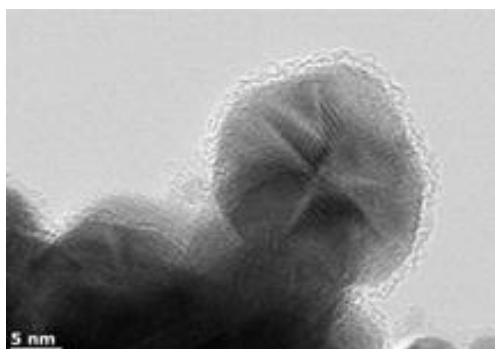
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Formulating solutions with nanomaterials

6. Precious metals

- Palladium



Product Name:	Palladium nanodispersion
Composition:	Pd
CAS #:	7440-05-3
Molecular weight:	106.42
Preparation:	Aqueous slurry
Appearance:	Black suspension
Particle size:	20-40 nm diameter (by TEM)
Morphology:	Spherical
Dispersion loading:	up to 10 wt %

Applications: Catalysis, diagnostics

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Formulating solutions with nanomaterials

FEASIBILITY STUDIES

Promethean Particles work with customers on feasibility studies to tailor a custom made solution for specific requirements. Please enquire for the cost of feasibility studies into alternative materials, such as investigation of other compositions, particle size, different morphologies, doping and/or surface coatings.

At the end of the feasibility study, the customer has the possibility to own foreground IP for the material in their application.

As the next step, the customer can:

- Manufacture the dispersion at their facilities (the customer's)
- Have their dispersion manufactured by Promethean Particles
- Utilize one of Promethean Particles' reactors under license

For more information on our reactor range, please consult our reactors brochure.

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