Electronic Supplementary Information(ESI†)

Synthesis of ultrathin metal oxide and hydroxide nanosheets using formamide in water at room temperature

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Synthesis recipes.

Nanomaterials	Precursor	Solvent	Reaction Concentration	Gas Diffusion Strategy	Reaction Temperature
$Co_3O_4/Co(OH)_2$	$CoCl_2$	water (20 mL) and formamide (20 mL)	20 mM	2 mL $NH_3·H_2O$	25 ℃
$Co_3O_4/Co(OH)_2$	$CoCl_2$	water (40 mL)	20 mM	2 mL $NH_3·H_2O$	25 ℃
γ-Fe_2O_3	$FeCl_2·4H_2O$	water (20 mL) and formamide (20 mL)	20 mM	2 mL $NH_3·H_2O$	25 ℃
γ-Fe_2O_3	$FeCl_2·4H_2O$	water (40 mL)	20 mM	2 mL $NH_3·H_2O$	25 ℃
Mn_3O_4	$MnCl_2·4H_2O$	water (20 mL) and formamide (20 mL)	200 mM	2 mL $NH_3·H_2O$	25 ℃
Mn_3O_4	$MnCl_2·4H_2O$	water (40 mL)	200 mM	2 mL $NH_3·H_2O$	25 ℃
ZnO	$ZnCl_2$	water (20 mL) and formamide (20 mL)	40 mM	2 mL $NH_3·H_2O$	25 ℃
ZnO	$ZnCl_2$	water (40 mL)	40 mM	2 mL $NH_3·H_2O$	25 ℃
$Cu(OH)_2·H_2O$	$Cu(CH_3COO)_2·H_2O$	water (20 mL) and formamide (20 mL)	200 mM	2 mL $NH_3·H_2O$	25 ℃
$Cu(OH)_2·H_2O$	$Cu(CH_3COO)_2·H_2O$	water (40 mL)	200 mM	2 mL $NH_3·H_2O$	25 ℃
$Mg(OH)_2/Mg_2(OH)_3Cl$	$MgCl_2·6H_2O$	water (30 mL) and formamide (10 mL)	200 mM	2 mL $NH_3·H_2O$	25 ℃
$Mg(OH)_2/Mg_2(OH)_3Cl$	$MgCl_2·6H_2O$	water (40 mL)	200 mM	2 mL $NH_3·H_2O$	25 ℃
$Mg(OH)_2/Mg_2(OH)_3Cl$	$MgCl_2·6H_2O$	water (30 mL) and ethanolamine (10 mL)	200 mM	2 mL $NH_3·H_2O$	25 ℃
$Mg(OH)_2/Mg_2(OH)_3Cl$	$MgCl_2·6H_2O$	water (30 mL) and ethylenediamine (10 mL)	200 mM	2 mL $NH_3·H_2O$	25 ℃
$Mg(OH)_2/Mg_2(OH)_3Cl$	$MgCl_2·6H_2O$	water (30 mL) and dimethyl formamide (10 mL)	200 mM	2 mL $NH_3·H_2O$	25 ℃

$Mg(OH)_2/Mg_2(OH)_3Cl$	$MgCl_2·6H_2O$	water (30 mL) and ethanol (10 mL)	200 mM	2 mL $NH_3·H_2O$	25 ℃
$Mg(OH)_2/Mg_2(OH)_3Cl$	$MgCl_2·6H_2O$	water (30 mL) and hydrazine (10 mL)	200 mM	2 mL $NH_3·H_2O$	25 ℃
$Mg(OH)_2/Mg_2(OH)_3Cl$	$MgCl_2·6H_2O$	40 mL water containing 0.1 g glycine	200 mM	2 mL $NH_3·H_2O$	25 ℃

Sample preparation for the measurement of solution phase ^{13}C NMR spectrum.

(a) for the sample of pure water after introducing NH_3: A vial containing 38 mL H_2O and 2 mL D_2O (internal reference) was sealed with parafilm and three pinholes were drilled allowing for gas diffusion. Subsequently, the vial was put into a sealed blue cap bottle (100 mL) with 2 mL concentrated ammonium hydroxide solution. After the diffusion for 12 hours at room temperature, 1 mL reaction solution was taken out as one sample and ^{13}C nuclear magnetic resonance spectrum of such sample was recorded immediately.

(b) for the sample of aqueous solution containing $MgCl_2$ after introducing NH_3: A solution containing precursor was prepared by dissolving $MgCl_2·6H_2O$ (200 mM) in the mixed solvent of 38 mL H_2O and 2 mL D_2O (internal reference). After ultrasonic dissolution, the vial was then sealed with parafilm and three pinholes were drilled allowing for gas diffusion. Subsequently, the vial was put into a sealed blue cap bottle (100 mL) with 2 mL concentrated ammonium hydroxide solution. After the diffusion for 12 hours at room temperature, 1 mL reaction solution was taken out as one sample and ^{13}C nuclear magnetic resonance spectrum of such sample was recorded immediately.

(c) for the sample of pure formamide aqueous solution: A mixed solvent of 28 mL H_2O, 2 mL D_2O (internal reference) and 10 mL formamide was prepared. Then, 1 mL reaction solution was taken out as one sample and ^{13}C nuclear magnetic resonance spectrum of such sample was recorded immediately.

(d) for the sample of formamide aqueous solution containing $MgCl_2$: A solution containing precursor was prepared by dissolving $MgCl_2·6H_2O$ (200 mM) in the mixed solvent of 28 mL H_2O, 2 mL D_2O (internal reference) and 10 mL formamide. After ultrasonic dissolution, 1 mL reaction solution was taken out as one sample and ^{13}C nuclear magnetic resonance spectrum of such sample was recorded immediately.

(e) for the sample of formamide aqueous solution after introducing NH_3 without $MgCl_2$: A vial containing 28 mL H_2O, 2 mL D_2O (internal reference) and 10 mL formamide was sealed with parafilm and three pinholes were drilled allowing for gas diffusion. Subsequently, the vial was put into a sealed blue cap bottle (100 mL) with 2 mL concentrated ammonium hydroxide solution. After the diffusion for 12 hours at room temperature, 1 mL reaction solution was taken out as one sample and ^{13}C nuclear magnetic resonance spectrum of such sample was recorded immediately.

(f) for the sample of formamide aqueous solution containing $MgCl_2$ after introducing NH_3: A

solution containing precursor was prepared by dissolving $MgCl_2 \cdot 6H_2O$ (200 mM) in the mixed solvent of 28 mL H_2O, 2 mL D_2O (internal reference) and 10 mL formamide. After ultrasonic dissolution, the vial was put into a sealed blue cap bottle (100 mL) with 2 mL concentrated ammonium hydroxide solution. After the diffusion for 12 hours at room temperature, 1 mL reaction solution was taken out as one sample and ^{13}C nuclear magnetic resonance spectrum of such sample was recorded immediately.

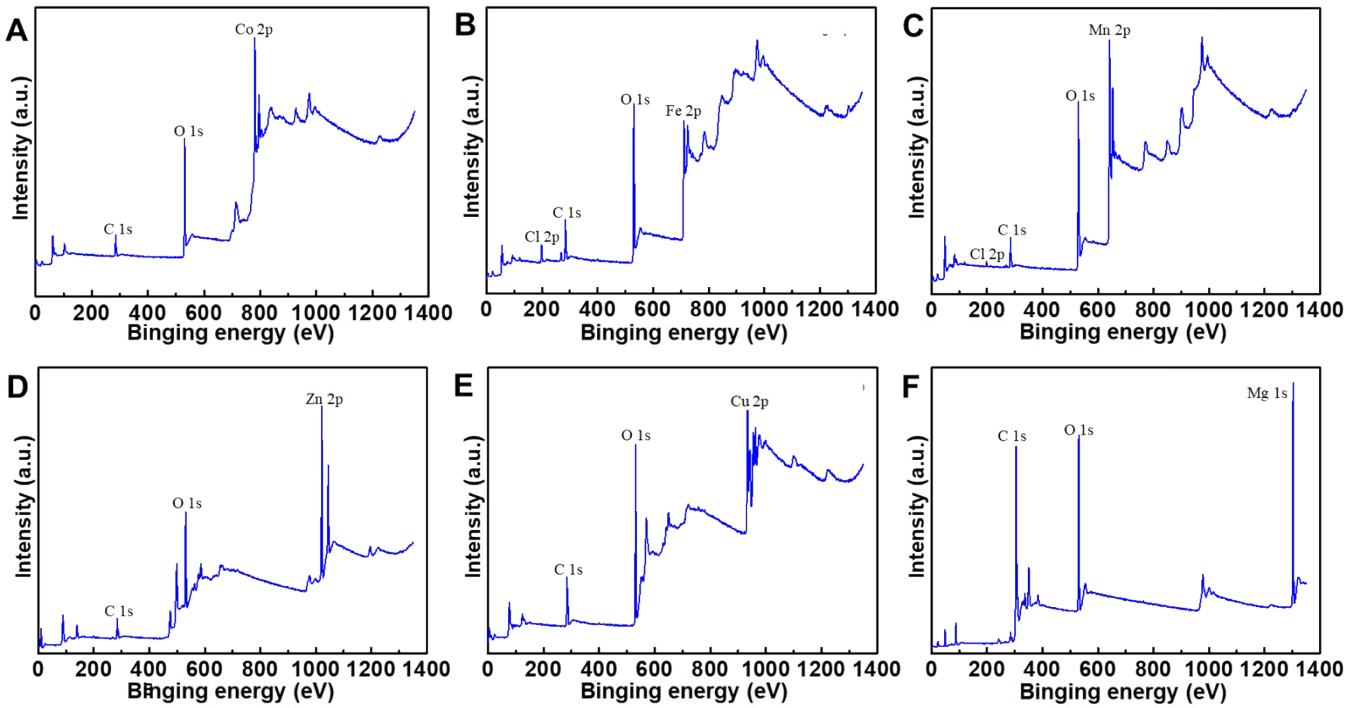
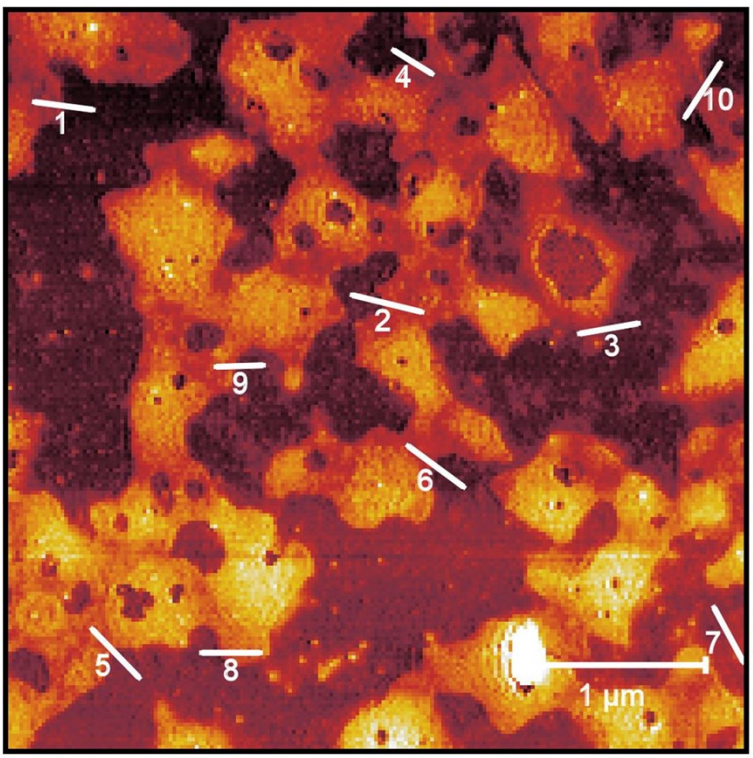
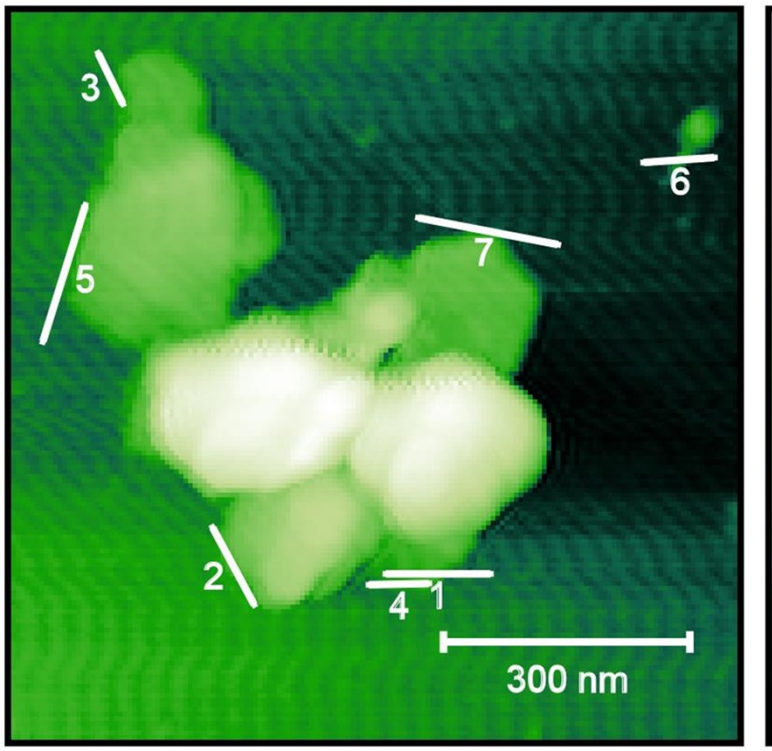


Fig. S1. XPS survey spectra of (A) $Co_3O_4/Co(OH)_2$, (B) γ-Fe_2O_3, (C) Mn_3O_4, (D) ZnO, (E) $Cu(OH)_2{\cdot}H_2O$ and (F) $Mg(OH)_2/Mg_2(OH)_3Cl$.



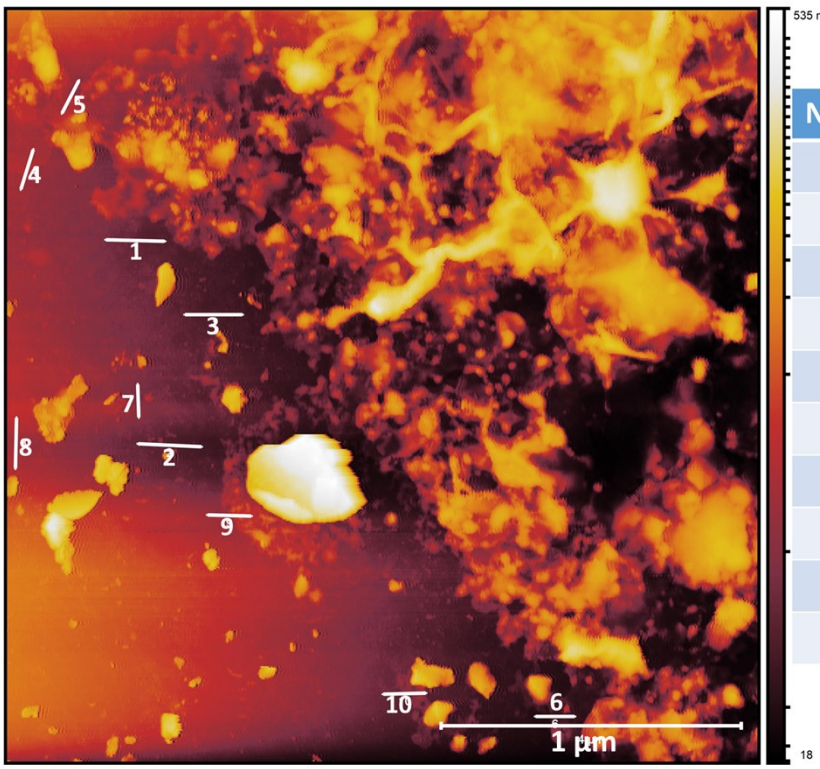
Number	Thickness
1	4.5 nm
2	3 nm
3	2.5 nm
4	3 nm
5	3 nm
6	3 nm
7	2 nm
8	4 nm
9	3.5 nm
10	3 nm

Fig. S2-1. AFM image of 2D $Co_3O_4/Co(OH)_2$ nanomaterials and the inset shows the corresponding thickness.



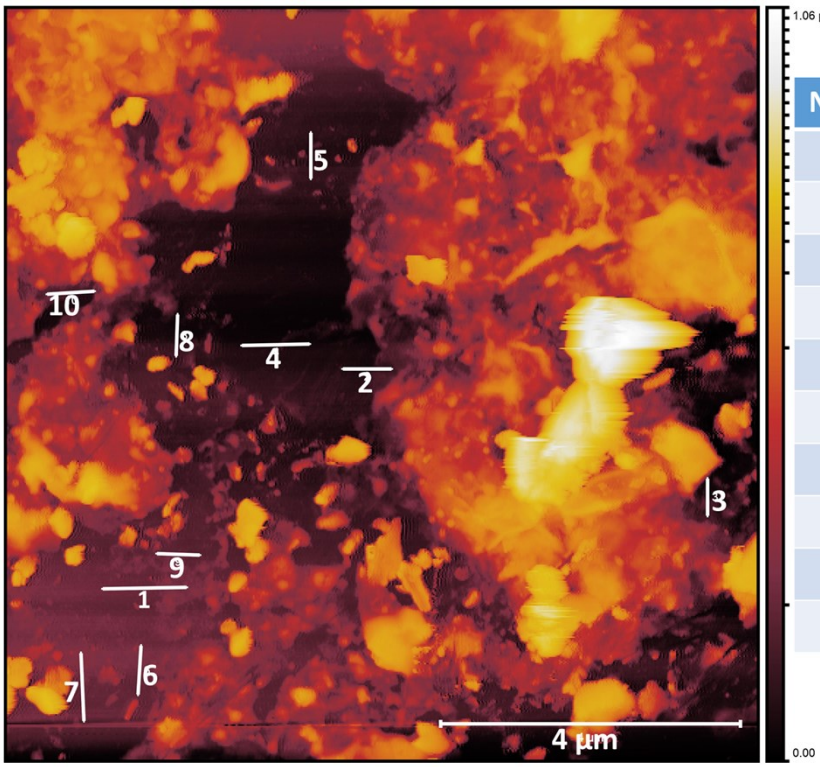
Number	Thickness
1	2.5 nm
2	2.5 nm
3	2 nm
4	2 nm
5	2 nm
6	4 nm
7	2.5 nm

Fig. S2-2. AFM image of 2D γ-Fe_2O_3 nanomaterials and the inset shows the corresponding thickness.



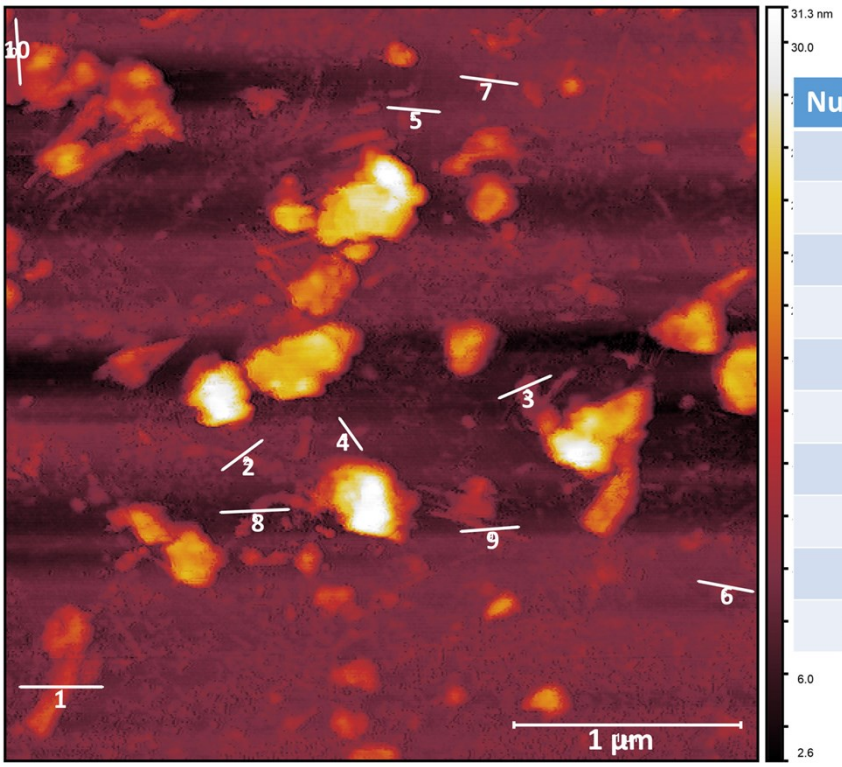
Number	Thickness
1	2.5 nm
2	2 nm
3	2.5 nm
4	3 nm
5	5 nm
6	6 nm
7	3 nm
8	3 nm
9	7 nm
10	5 nm

Fig. S2-3. AFM image of 2D Mn_3O_4 nanomaterials and the inset shows the corresponding thickness.



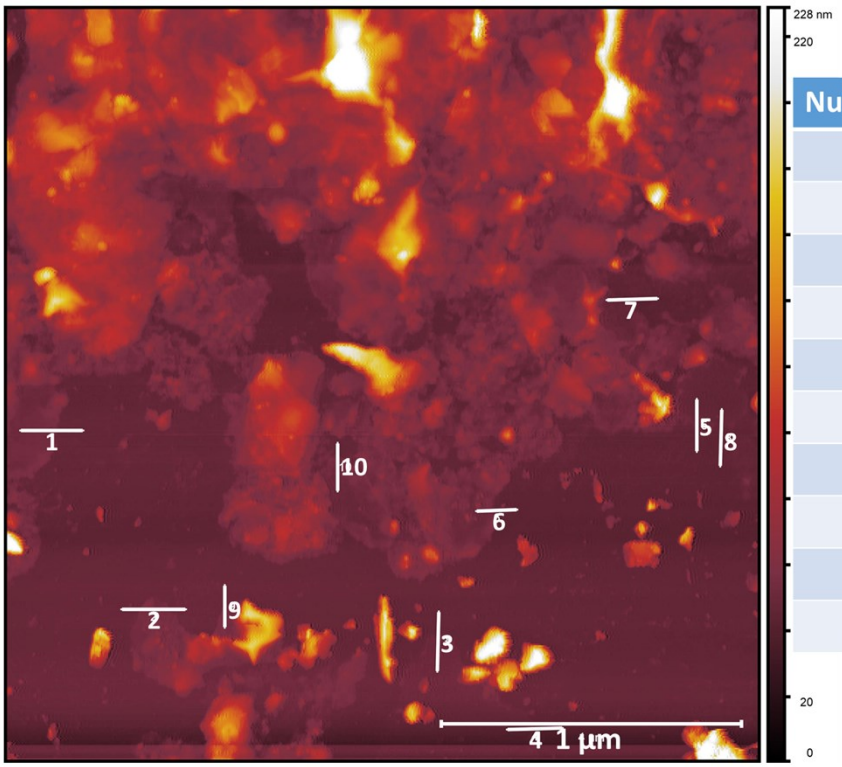
Number	Thickness
1	3 nm
2	4.5 nm
3	5 nm
4	5 nm
5	3 nm
6	3 nm
7	4 nm
8	7 nm
9	3 nm
10	3 nm

Fig. S2-4. AFM image of 2D ZnO nanomaterials and the inset shows the corresponding thickness.



Number	Thickness
1	5 nm
2	2 nm
3	5 nm
4	2 nm
5	1 nm
6	2 nm
7	3 nm
8	4 nm
9	3 nm
10	4 nm

Fig. S2-5. AFM image of 2D $Cu(OH)_2 \cdot H_2O$ nanomaterials and the inset shows the corresponding thickness.



Number	Thickness
1	5 nm
2	5 nm
3	3 nm
4	3 nm
5	3 nm
6	5 nm
7	3 nm
8	3 nm
9	5 nm
10	5 nm

Fig. S2-6. AFM image of 2D $Mg(OH)_2/Mg_2(OH)_3Cl$ nanomaterials and the inset shows the corresponding thickness.

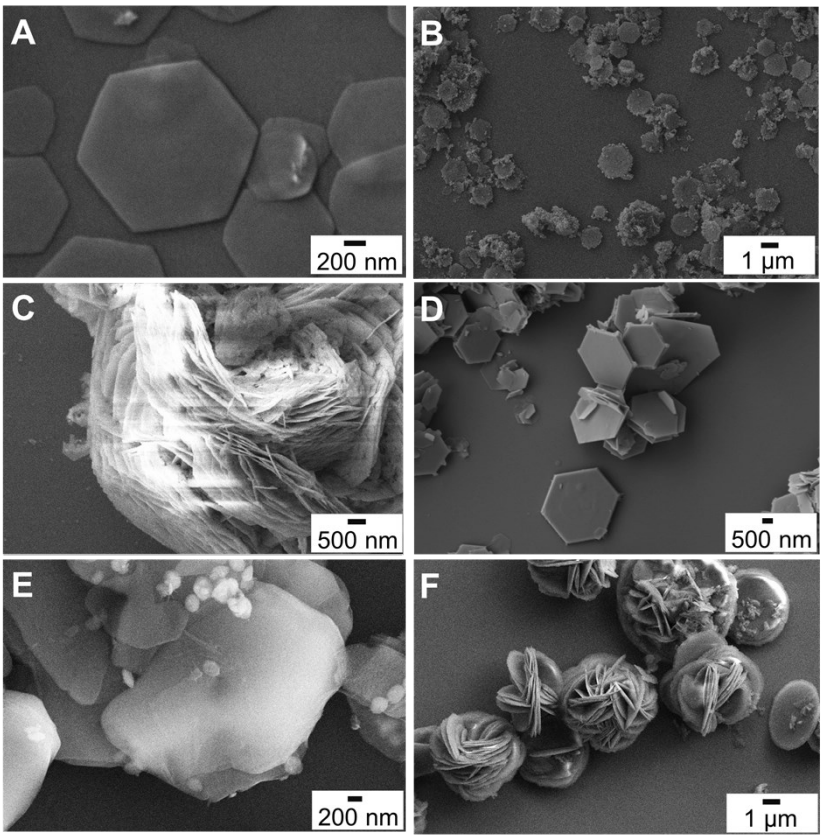


Fig. S3. SEM images of nanomaterials synthesized in water. (A) cobalt hydroxide, (B) ferric oxide, (C) manganese oxide, (D) zinc hydroxide, (E) copper hydroxide and (F) $Mg(OH)_2$ nanomaterials.

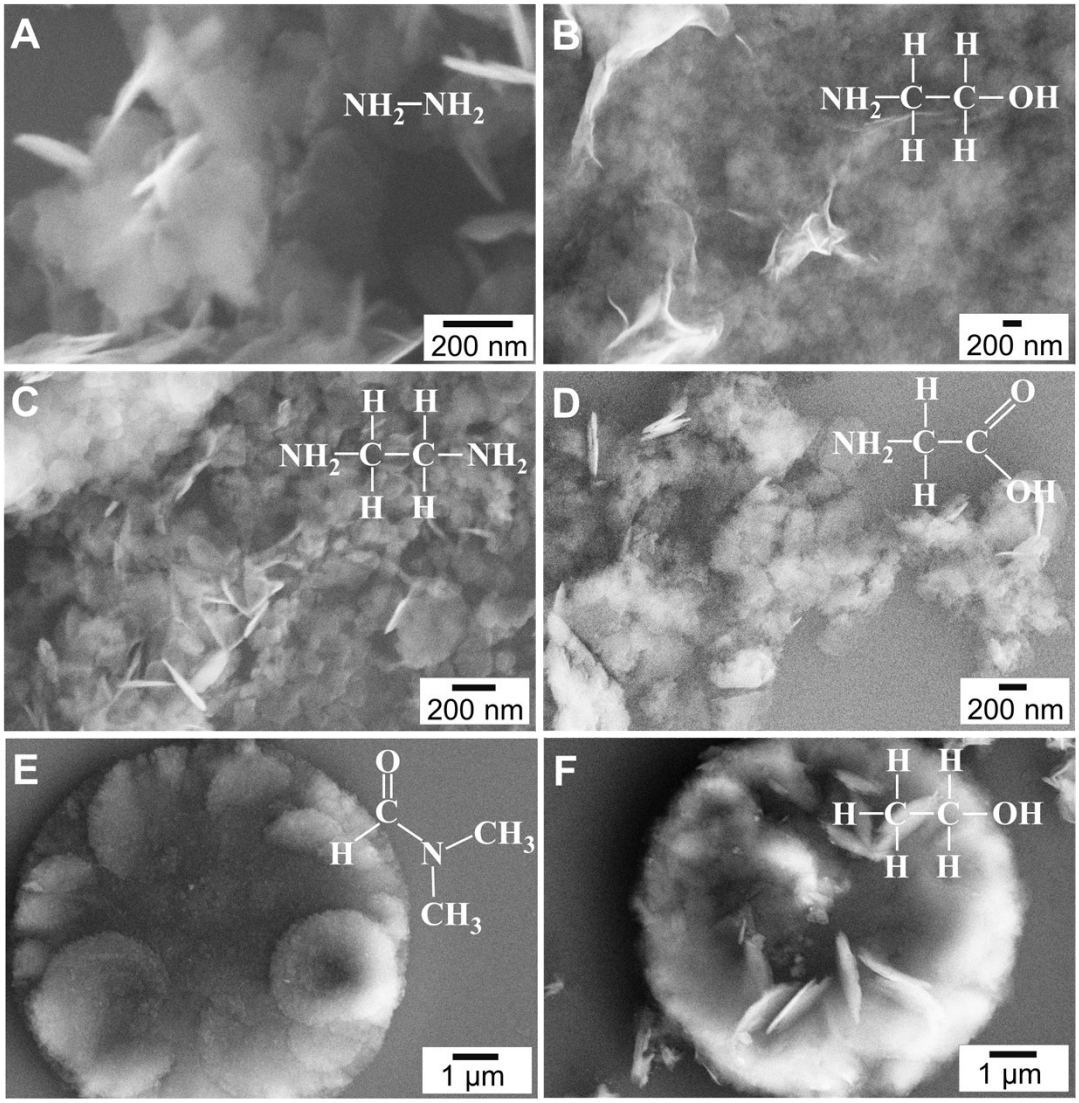


Fig. S4. The molecular formula of organic solvent and SEM image of 2D $Mg(OH)_2$ nanomaterials obtained in different mixed solvents. (A) water and hydrazine, (B) water and ethanolamine, (C) water and ethylenediamine, (D) aqueous solution of glycine, (E) water and dimethyl formamide and (F) water and ethanol.

Table. S1. The relative polarity of different solvents.

Solvent	Relative polarity	Reference
Water	9	https://www.chemicalbook.com/
Formamide	7.3	https://www.chemicalbook.com/
Ethanolamine	0.651	https://www.chemicalbook.com/
Ethylenediamine	/	/
Glycine	/	/
Hydrazine	/	/
Dimethyl Formamide	0.386	https://www.chemicalbook.com/
Ethanol	0.654	https://www.chemicalbook.com/

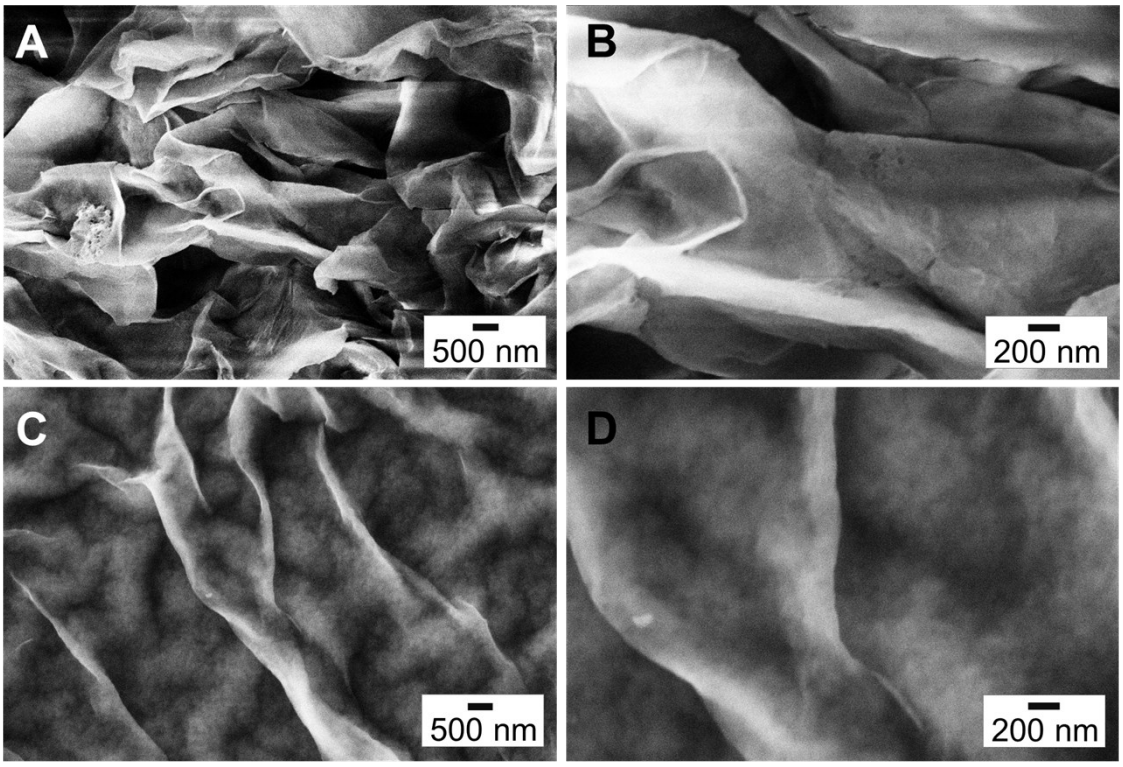


Fig. S5. SEM images of ultrathin $Mg(OH)_2/Mg_2(OH)_3Cl$ nanosheets obtained by introducing NH_3 into formamide aqueous solution containing $MgCl_2$ via different ways. (A-B) NH_3-diffusion method using 2 mL concentrated $NH_3 \cdot H_2O$ (14.8 mol/L) as the alkaline source. (C-D) One-off addition of 2 mL concentrated $NH_3 \cdot H_2O$ (14.8 mol/L).