Co-reduction Synthesis of \( r \)-GO Sheet/Au Composites by \( \gamma \)-Radiation and their Catalytic Properties

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About γ-ray radiation synthesis

Co-reduction synthesis of GO Sheet/AuNP composites

Group related works

Acknowledgments
About $\gamma$-ray radiation synthesis

Principles: Irradiation of water by $\gamma$-ray
Advantages of γ-radiation method

→ Mild synthesis condition: room temp., ambient pressure;
→ No reduction or oxidation reagents;
→ No initiators, very pure products;
→ Reaction yield;
→ ……

The reaction products are uniformly distributed in the system, and the particle size distribution of the products well done.

For inorganic/polymer composites: the formation of nano-materials and polymers can be synchronized (or one-step).

Many products to achieve industrial production: Teflon wire cable, dyeing and printing auxiliary, battery separator etc.
How to control the synthesis system with reductive surroundings?

—— Reductive atmosphere(surroundings)

Purging \( N_2 \) and adding iso-propanol or other kind of alcohols and to scavenge oxidative free radicals such as \( \bullet \text{OH}, \text{H}_2\text{O}_2 \) etc.

\[
(\text{CH}_3)_2\text{CHOH} + \bullet \text{OH} \rightarrow (\text{CH}_3)_2\text{CHO} \bullet + \text{H}_2\text{O}
\]

or

\[
(\text{CH}_3)_3\text{COH} + \bullet \text{OH} \rightarrow (\text{CH}_3)_3\text{CO} \bullet + \text{H}_2\text{O}
\]

Main species in this case: \( e^-_{aq} \), \( \bullet \text{H} \) and other reductive species

\( e^-_{aq} \) Redox potential (-2.77V)

\[
M^{n+} + e^-_{aq} (\text{or } \bullet \text{H}) \rightarrow M^{n-1} \rightarrow M^{n-2} \rightarrow \ldots \rightarrow M^0 (\text{nano – particle})
\]

\[
nM^0 \rightarrow M_n (\text{Cluster})
\]

\[
G_{\text{red}}(\text{max}) = G_{e^-_{aq}} + G_{\text{H}^\bullet} + G_{\text{OH}^\bullet} \approx 0.6 \mu\text{mol J}^{-1}
\]
How to control the synthesis system with oxidative surroundings?

—— Oxidative atmosphere (surroundings)

*Bubbling N$_2$O about 10 min,* \[ e^{-}_{aq} + N_2O + H_2O \rightarrow N_2 + \bullet OH + OH^- \]

**Main species in this case:** •OH, H$_2$O$_2$ etc. *Pulse radiolysis*
Why do we synthesize?

r-GO Sheet/Au NP Composites

GO/Noble-metal NP: optical, electrical and excellent catalytic performance

SERS Effect: surface-enhanced Raman scattering
**Co-reduction synthesis of composites**

\[ \text{Au}^{3+} \text{isopropanol} \rightarrow \gamma\text{-ray} \rightarrow \text{r-GO/AuNP Composite} \]

\[ \text{HAuCl}_4 \]

Chloroauric acid

Fig: Most of the oxygen-containing groups had been removed after irradiation.
**Co-reduction synthesis of composites**

 Preparation of r-GO/Au nanocomposite through γ-irradiation

TEM of r-GO/AuNP at different concentrations of Au³⁺ (b, c, d)

Unpublished work
Unpublished work

Fig. The TGA spectra of GO (a), r-GO (b), r-GO Sheet/Au (c,d)

G, GO and r-GO

r-GO/AuNP

XRD
Catalytic property study: r-GO/AuNP composite

Catalytic reduction of p-nitrophenol by NaBH₄ (sodium borohydride)

\[
- \frac{dc_t}{dt} = k_{\text{app}} c_t
\]

Unpublished work

\[
k_{\text{app}}: 1.18 \times 10^{-3} \text{ s}^{-1}, 1.35 \times 10^{-3} \text{ s}^{-1}
\]
Group related works

Photo-thermal sensitive PNIPAM/GO nanocomposite hydrogel

by in situ $\gamma$-radiation-assisted polymerization of aqueous solution of N-isopropylacrylamide and graphene oxide.
**Group related works**

*Thermosensitive poly (N-isopropylacrylamide)/Au nanoparticles (PNIPAM/Au NPs) nanocomposite hydrogels (One-step)*

**excellent catalytic performance**

Preparation of composite hydrogel through $\gamma$-radiation
Group related works

Reaction time ↑, absorbance ↓, o-nitroaniline was reduced.

excellent catalytic performance
※ **Group related works**

PNIPAM/Fe$_3$O$_4$ Ferromagnetic hydrogel
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