Electrode processes associated with the electrolytic production of Ni frommolten oxides

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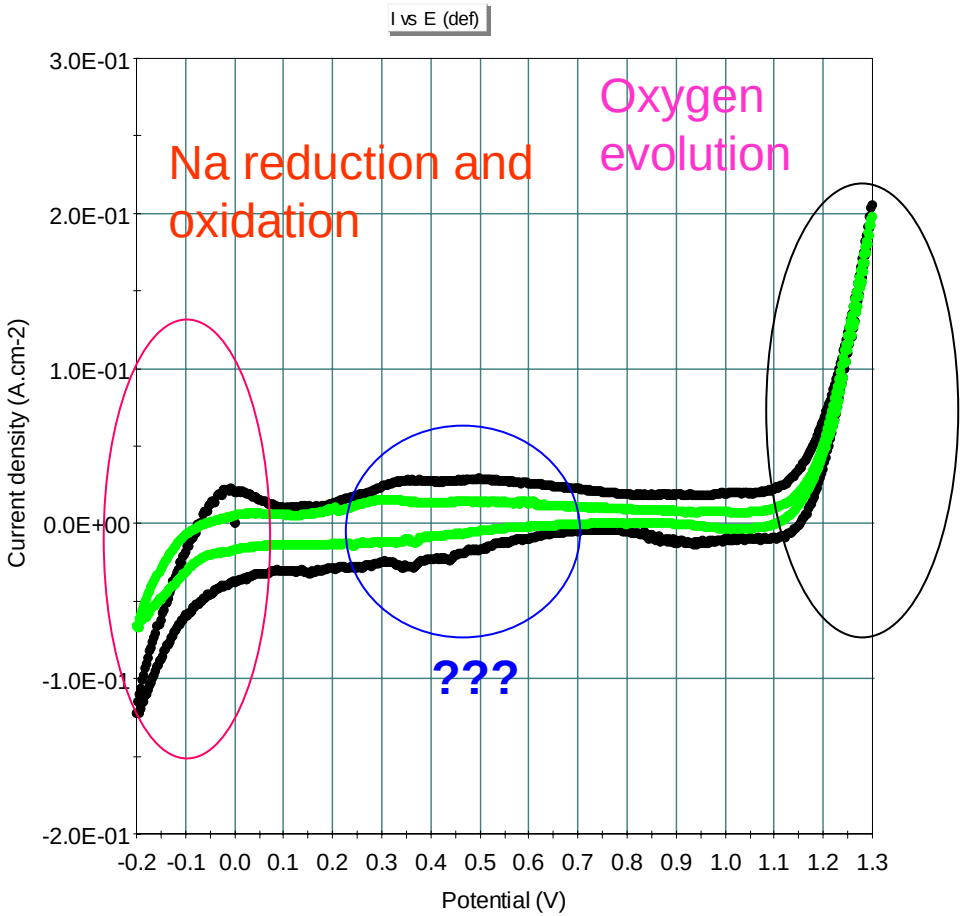
Purpose of research

- Professor Sadoway has proposed producing liquid Fe and further stainless steel by MOE (Sadoway MIT Process).
- We are trying to find the possibility of co-reduction of Fe, Ni and Cr from their oxides by MOE.
- “low-temperature” electrochemical measurements necessary of Ni redox will provide useful guidance for high-temperature efforts to produce liquid stainless steel.

Experimental setup

- Three electrode system has been applied.
- working electrode is Pt shielded by BN, counter electrode is Pt plate.
- reference electrode is Fe^{2+}/Fe separate BN chamber
- Electrochemical data were measured by Parstat 2273.

Supporting electrolyte CV



Scan rate (mV/s):

Green line : 5, Black line: 50

Electrolyte composition:

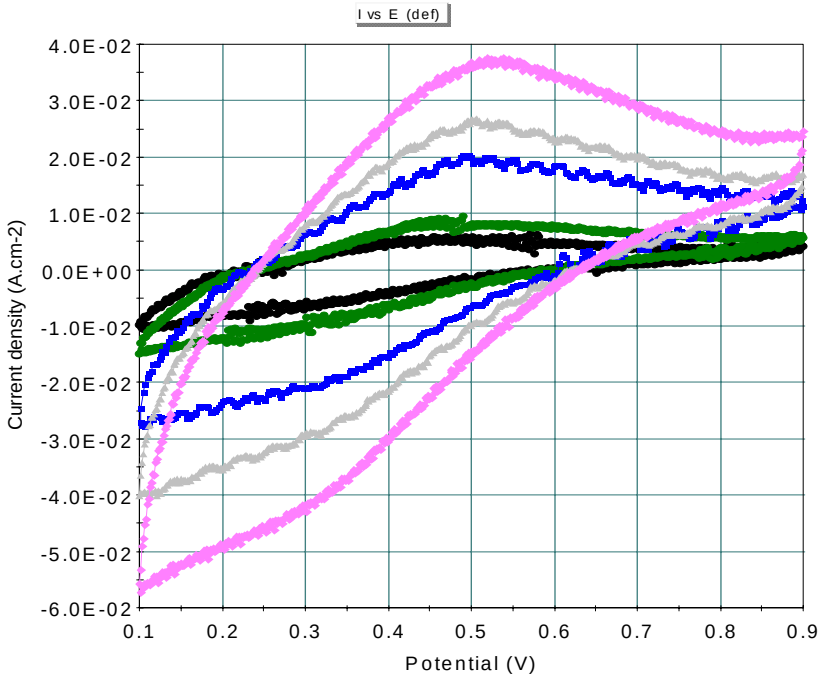
Na_2O , B_2O_3, SiO_2

WE: Pt ($0.12cm^2$)

Standard decomposition potential

(at 850ºC)

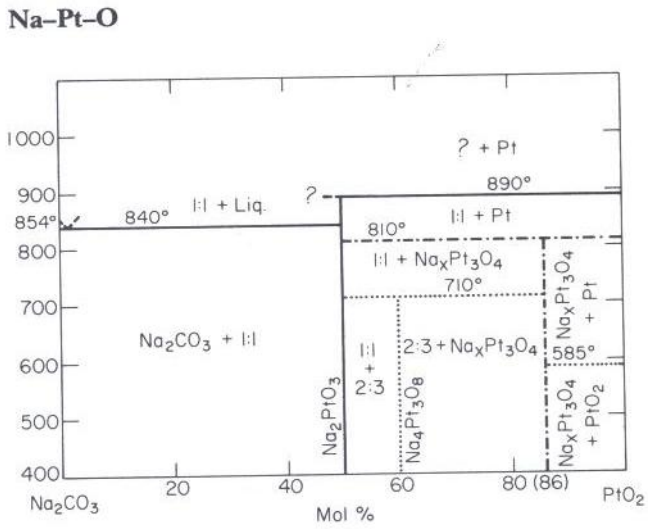
$Na_2O=2Na+0.5O_2$ (g)	-1.37V
$B_2O_3=2B+1.5O_2$ (g)	-1.72V
$SiO_2=Si+O_2$ (g)	-1.84V
$NiO=Ni+0.5O_2$ (g)	-0.71V
$FeO=Fe+0.5O_2$ (g)	-0.99V

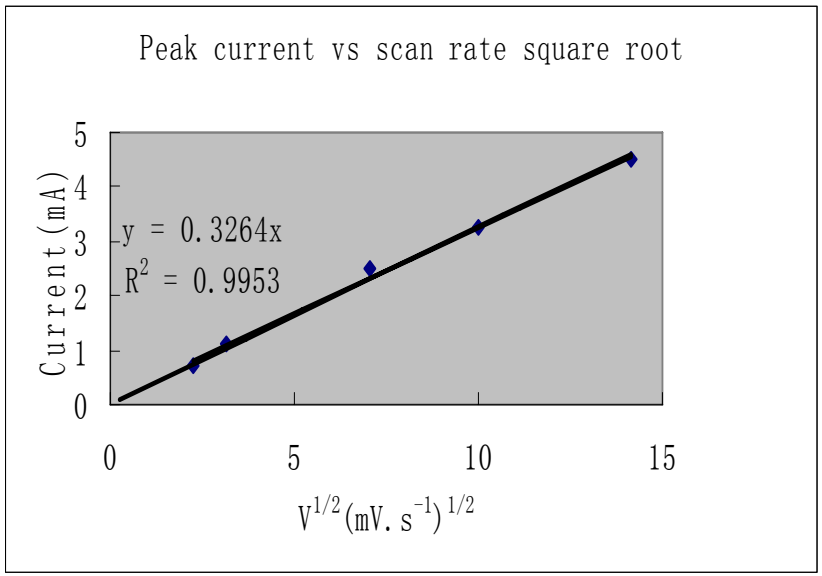


Scan rate (mV/s): Black line: 5

Green line: 25, Blue line: 50

Light gray line: 100, Pink line: 200

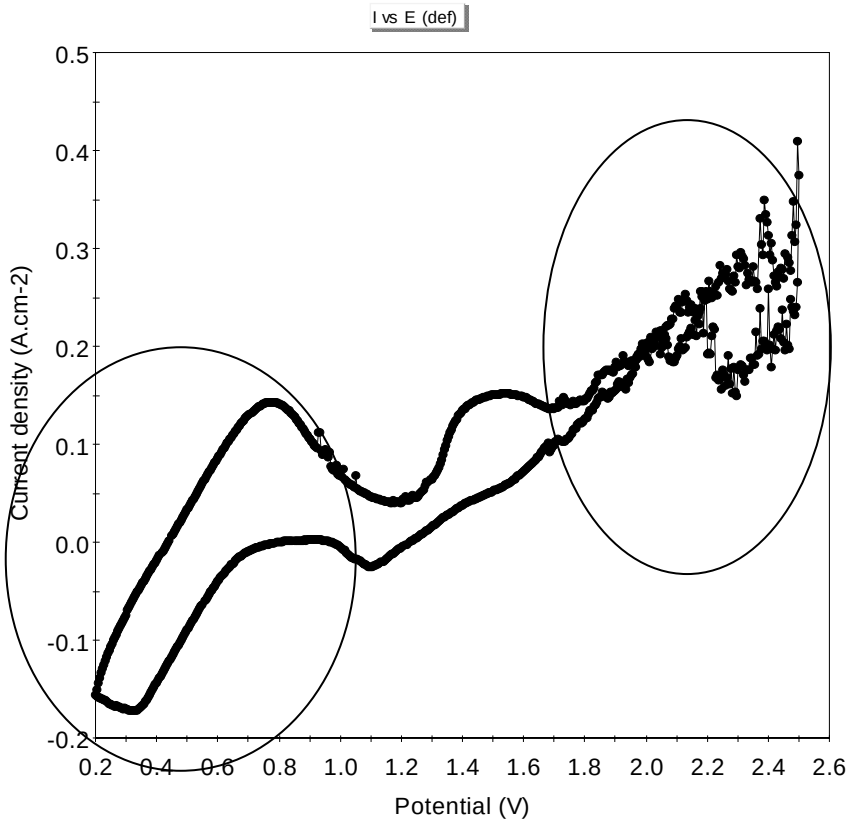




The electrode process is quasi-reversible. we speculate that the peaks are related to

$PtO_2 + 4e \leftrightarrow Pt + 2O^{2-}$

CV for electrolyte containing NiO



Scan rate: 50mV/s

Electrolyte composition

$Na_2O+B_2O_3+SiO_2+NiO$

WE: Pt shielded by BN

CE: Pt plate

RE: Fe2+/Fe separate BN chamber

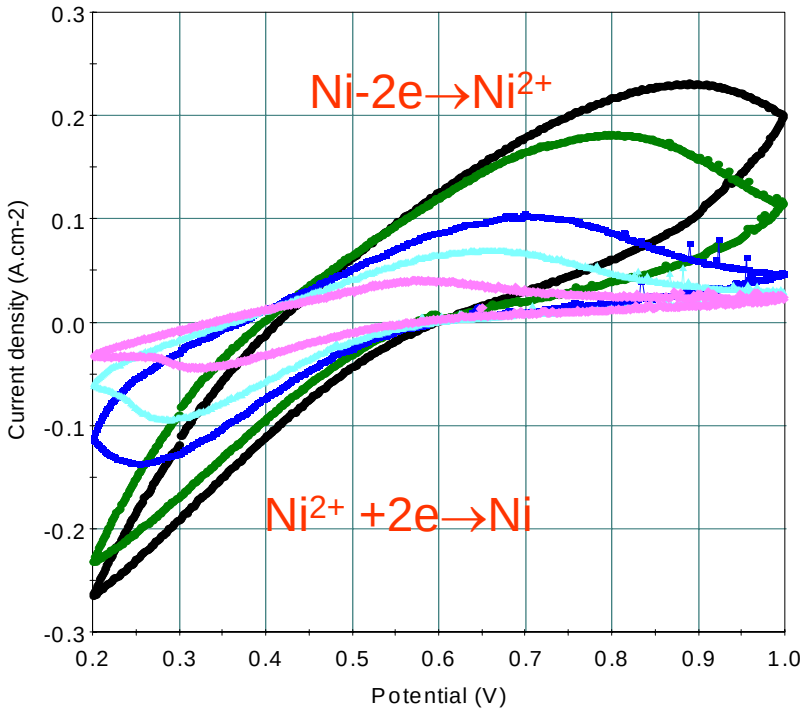
T: 850℃

standard decomposition potential at 850℃

NiO = Ni + 0.5O2 (g) : -0.71 V

FeO=Fe+0.5O2 (g) -0.99V

Ni deposition and stripping



Scan rate: mV/s

Pink line: 10

Light blue line:50

Blue line: 100

Green line: 300

Black line: 500

standard decomposition potential at 850℃

$NiO = Ni + 0.5O_2$ (g) : -0.71 V

$FeO=Fe+0.5O_2$ (g) -0.99V

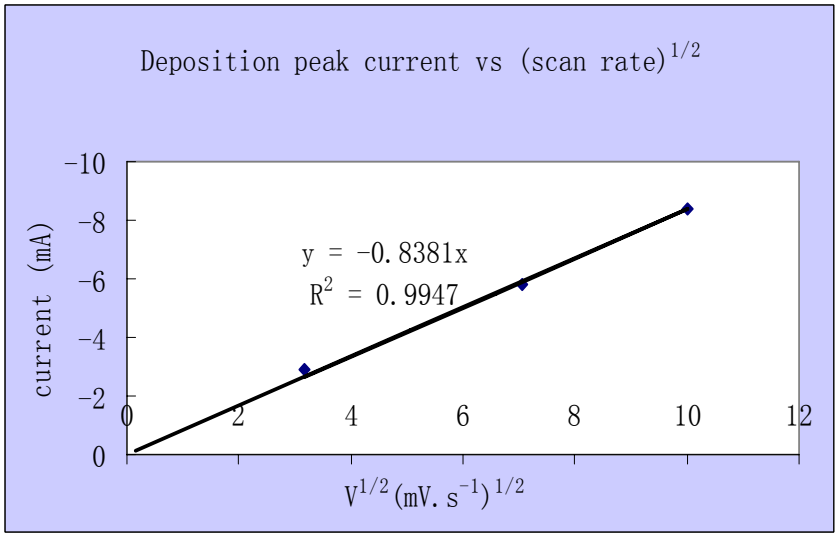
onset Ni reduction potential is 0.6V vs Fe^{2+}/Fe

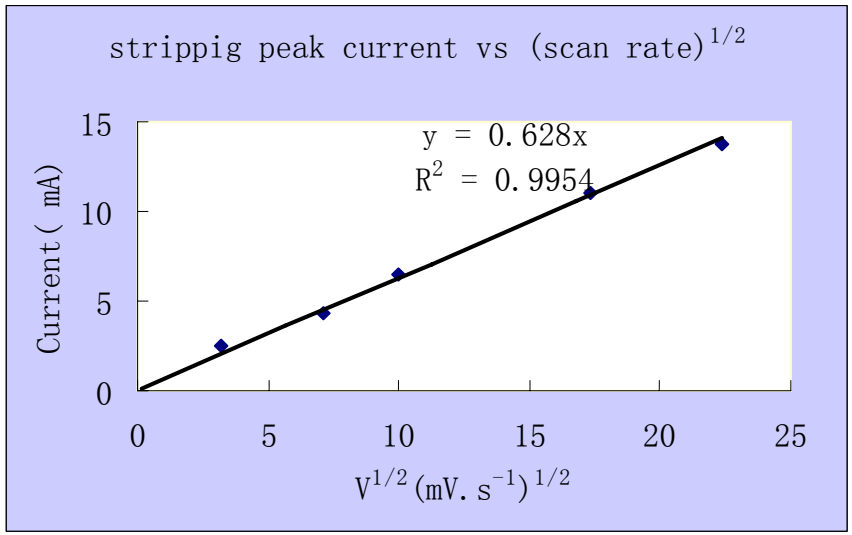
Electrolyte composition:

$Na_2O+B_2O_3+ SiO_2$,+5% NiO

WE: Pt (0.12 cm^2)

Ni deposition is quasi-reversible



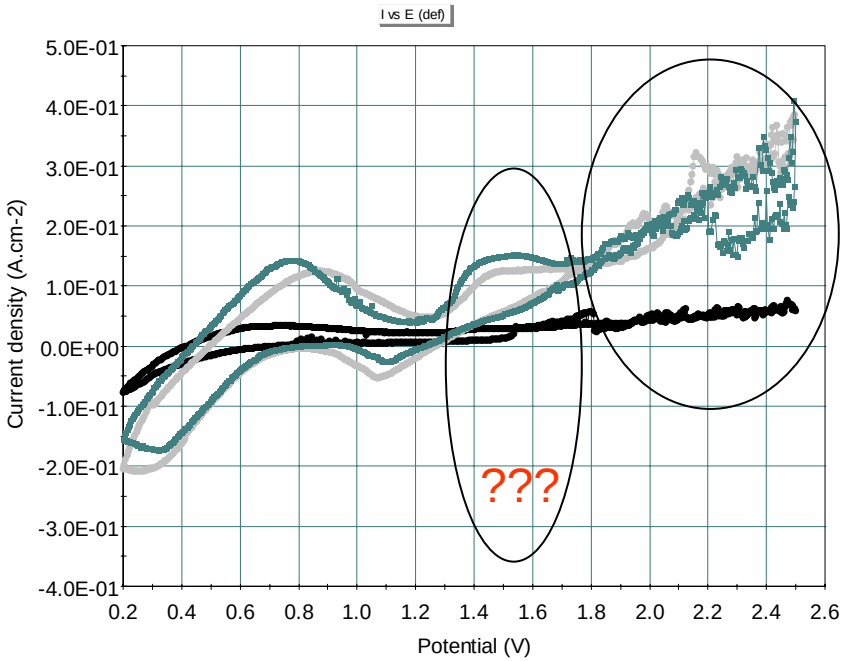


Deposition and stripping peak potentials change with scan rate. So electrode process is controlled by a mix of diffusion-controlled mass transport of Ni^{2+}

and a slow step at the electrode/electrolyte interface

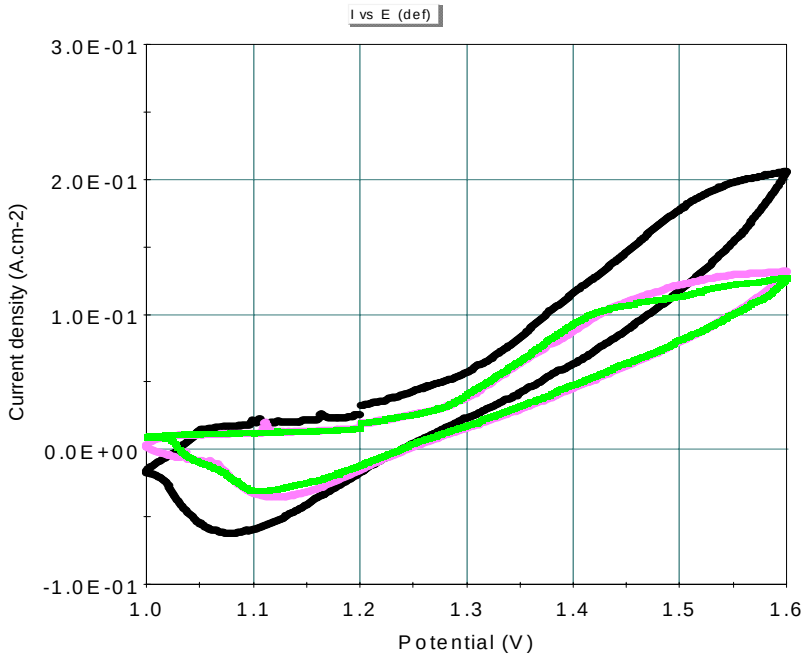
Complex oxygen-ion adsorption and oxygen evolution

Electrolyte composition: $Na_2O+B_2O_3+SiO_2+NiO$



Scan rat(mV/s) 10,50, 100

Oxygen evolution

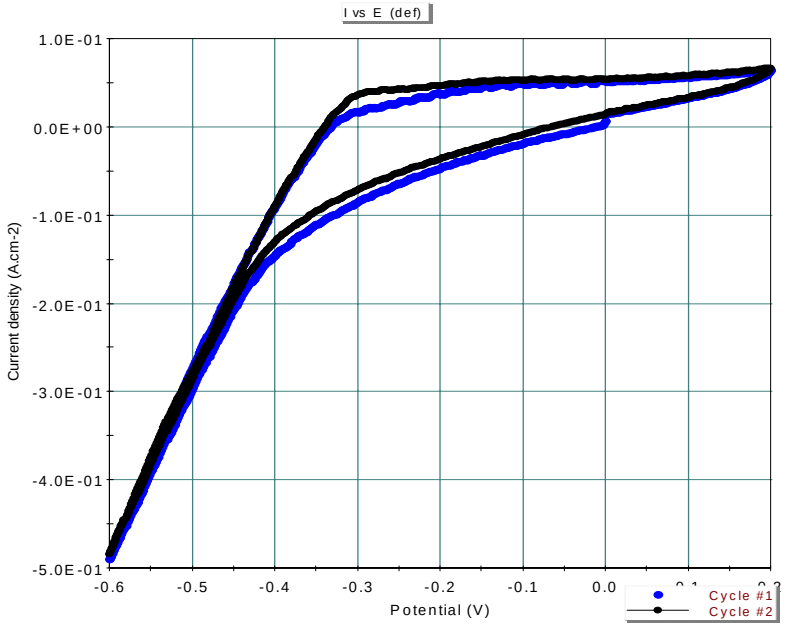


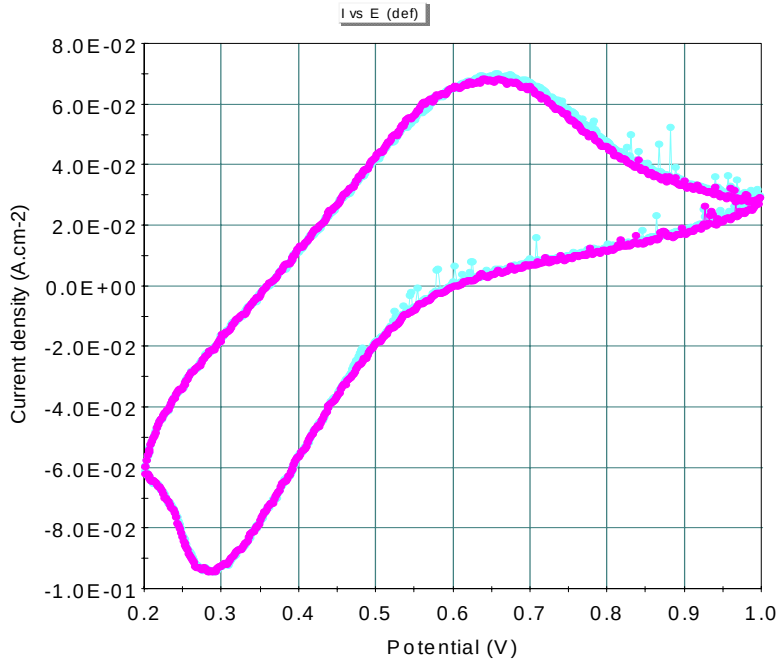
Scan rate(mV/s) :300, 100, 50

we speculate the peaks related to

Complex oxygen ion adsorption and desorption

The potential difference between Na and Ni deposition





Electrolyte composition

Na2O+B2O3+SiO2

WE:Pt

Scan rate: 50mV/s

Electrolyte composition:

Na2O+B2O3+ SiO2,+NiO

WE:Pt

Scan rate :50mV/s

Summary

- Potential window of Supporting electrolyte sustains Ni deposition from NiO.
- Ni deposition possible from oxides melts
- Ni deposition is controlled by a mix of
  - diffusion-controlled mass transport of Ni^{2+}
  - and a slow step at the electrode/electrolyte interface,

Acknowledgments

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Thank you for your attention