Claims

1. A method of electrochemically reducing multiple metal oxide pellets simultaneously, the method comprising:

- contacting an anode and a first cathode with an electrolyte;
- applying an electrical potential between the anode and the first cathode;
- contacting the anode and a second cathode with multiple metal oxide pellets with the electrolyte, wherein the multiple metal oxide pellets are secured to the second cathode; and
- applying an electrical potential between the anode and the second cathode to reduce multiple metal oxides comprised in the multiple metal oxide pellets to its respective metals,

wherein each of the multiple metal oxide pellets comprises multi-elemental oxides.

2. The method according to claim 1, further comprising removing the first cathode prior to the contacting the anode and a second cathode.

3. The method according to claim 1 or 2, wherein each of the multiple metal oxide pellets has a porosity of 5-60%.

4. The method according to any preceding claim, wherein each of the multiple metal oxide pellets has same or different composition from each other.

5. The method according to any preceding claim, wherein the multi-elemental oxide comprises: titanium oxide (TiO_2), cobalt oxide (CoO), chromium oxide (Cr_2O_3), iron oxide (Fe_2O_3), nickel oxide (NiO), aluminium oxide (Al_2O_3), manganese oxide (MnO_2), niobium pentoxide (Nb_2O_5), tin (IV) oxide (SnO_2), tantalum pentoxide (Ta_2O_5), terbium (III) oxide (Tb_2O_3), lanthanum oxide (La_2O_3), zirconium dioxide (ZrO_2), silicon dioxide (SiO_2), vanadium pentoxide (V_2O_5), vanadium dioxide (VO_2), vanadium trioxide (V_2O_3), ytterbium oxide (Yb_2O_3), dysprosium oxide (Dy_2O_3), erbium oxide (Er_2O_3), samarium oxide (Sm_2O_3), gadolinium oxide (Gd_2O_3), germanium dioxide (GeO_2), magnesium oxide (MgO), neodymium oxide (Nd_2O_3), lithium superoxide (LiO_2), cerium oxide (CeO_2), copper oxide (CuO), uranium dioxide (UO_2), triuranium octoxide (U_3O_8), hafnium dioxide (HfO_2), tungsten trioxide (WO_3), $NiAl_2O_4$, $SrTiO_3$, $FeTiO_3$, $CaWO_4$, or a combination thereof.

6. The method according to any preceding claim, wherein the method is carried out under an inert atmosphere.

7. The method according to claim 6, wherein the inert atmosphere comprises argon.

8. The method according to any preceding claim, wherein the applying is for a pre-determined period of time.

9. The method according to any preceding claim, wherein the cathode comprises titanium (Ti), stainless steel, molybdenum, nickel, iron-chromium-aluminium (FeCrAl) alloy, or a combination thereof.

10. The method according to any preceding claim, wherein the anode comprises graphite, glassy carbon, $CaRuO_3$, SnO_2, or a combination thereof.

11. The method according to any preceding claim, wherein the pellet has an average size of 2-100 mm.

12. The method according to any preceding claim, wherein the electrolyte comprises a molten salt.

13. The method according to claim 12, wherein the molten salt comprises calcium chloride ($CaCl_2$), lithium chloride (LiCl), lithium oxide (Li_2O), sodium chloride (NaCl), calcium oxide (CaO), lithium bromide (LiBr), potassium bromide (KBr), cesium bromide (CsBr), calcium bromide ($CaBr_2$), potassium chloride (KCl), potassium bromide (KBr), or a combination thereof.

14. The method according to any preceding claim, further comprising heating the electrolyte prior to the contacting.

15. The method according to claim 14, wherein the heating comprises melting the electrolyte to a molten state.

16. The method according to any preceding claim, wherein the electrolyte is at a temperature of 400-1200°C prior to the contacting.

17. The method according to any preceding claim, further comprising collecting the multiple metal oxide pellets following the applying to recover the metals.

18. An electrochemical cell for electrochemically reducing multiple metal oxide pellets simultaneously, the cell comprising:

- an electrolyte;
- an anode;
- a first cathode configured to move between a first position and a second position, wherein the first cathode is in contact with the electrolyte in the first position and the first cathode is not in contact with the electrolyte in the second position;
- a second cathode comprising multiple metal oxide pellets secured to the second cathode, the second cathode configured to move between a first position and a second position, wherein the second cathode is not in contact with the electrolyte in the first position and the second cathode is in contact with the electrolyte in the second position; and
- a power supply for applying an electrical potential between the anode and the cathode to reduce multiple metal oxides comprised in the multiple metal oxide pellets to its respective metals

wherein the first cathode and the second cathode are not simultaneously in contact with the electrolyte, and

wherein each of the multiple metal oxide pellets comprises multi-elemental oxides.

19. The electrochemical cell according to claim 18, wherein the electrolyte is a molten electrolyte.

20. The electrochemical cell according to claim 18 or 19, wherein each of the multiple metal oxide pellets have same or different composition from each other.

21. The electrochemical cell according to any of claims 18 to 20, wherein the multi-elemental oxide comprises: titanium oxide (TiO_2), cobalt oxide (CoO), chromium oxide (Cr_2O_3), iron oxide (Fe_2O_3), nickel oxide (NiO), aluminium oxide (Al_2O_3), manganese

oxide (MnO_2), niobium pentoxide (Nb_2O_5), tin (IV) oxide (SnO_2), tantalum pentoxide (Ta_2O_5), terbium (III) oxide (Tb_2O_3), lanthanum oxide (La_2O_3), zirconium dioxide (ZrO_2), silicon dioxide (SiO_2), vanadium pentoxide (V_2O_5), vanadium dioxide (VO_2), vanadium trioxide (V_2O_3), ytterbium oxide (Yb_2O_3), dysprosium oxide (Dy_2O_3), erbium oxide (Er_2O_3), samarium oxide (Sm_2O_3), gadolinium oxide (Gd_2O_3), germanium dioxide (GeO_2), magnesium oxide (MgO), neodymium oxide (Nd_2O_3), lithium superoxide (LiO_2), cerium oxide (CeO_2), copper oxide (CuO), uranium dioxide (UO_2), triuranium octoxide (U_3O_8), hafnium dioxide (HfO_2), tungsten trioxide (WO_3), $NiAl_2O_4$, $SrTiO_3$, $FeTiO_3$, $CaWO_4$, or a combination thereof.