SUVNING PARCHALANISHIDAN VODOROD GAZINI OLISH UCHUN SEOLIT LTA BILAN TiO_2 NING KOMPOZITSION FOTOKATALITIK BIRIKMASI

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ANNOTATSIYA

Vodorod energetikasi toza va barqaror energiya ekanligi sababli yaqin kelajakda eng istiqbolli energiya manbai hisoblanadi. Nano o'lchamdagi fotokatalizatorlar bilan suvni bo'linish oddiygina suvda tarqalgan fotokatalizator kukunidan foydalanadi. Fotokatalitik suvning bo'linish tamoyillari elektronni qo'zg'atish va yig'ish uchun yuqori sirt maydonlarini talab qiladi. Kataliz, adsorbsiya va ajratish sohalarida keng qo'llaniladigan seolitlarning maxsus tuzilishi va xususiyatlari tufayli samarali fotokatalitik faollik ko'rsatishi kutilmoqda. Ushbu sharhda LTA tipidagi seolit fotokatalizatorlarning afzalliklari va seolitlarning fotokatalizda qo'llanilishini o'rganish holati mos ravishda kiritilgan va ta'kidlangan.

Kalit so'zlar: Seolit asosidagi fotokatalizator; Fotokataliz; Vodorod; Suvning bo'linishi; Ko'rinadigan yorug'lik;

PHOTOCATALYTIC COMPOSITE COMPOUND OF TiO_2 WITH ZEOLITE LTA FOR HYDROGEN GAS PRODUCTION FROM WATER SPLITTING

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ABSTRACT

Hydrogen energy is the most promising energy source in the near future because it is a clean and sustainable energy. Water splitting with nanoscale photocatalysts simply uses photocatalyst powder dispersed in water. Photocatalytic water splitting principles require high surface areas for electron excitation and collection. Widely used in the fields of catalysis, adsorption and separation, zeolites are expected to exhibit effective photocatalytic activity due to their special structure and properties. In this review, the advantages of LTA-type zeolite photocatalysts and the state of research on the application of zeolites in photocatalysis are respectively introduced and highlighted.

Keywords: Seolite-based photocatalyst; Photocatalysis; Hydrogen; Water splitting; Visible light;

KIRISH

Vodorod ishlab chiqarish uchun bir nechta usullar qo‘llanilgan bo‘lsa-da, fotokatalitik vodorod hosil bo'lishiga bugungi kunlarda katta e’tibor qaratildi. Ushbu usul quyosh energiyasini to‘plashni suvning bo‘linishi bilan birlashtiradi, shuning uchun bu suv elektroliz jarayoni bilan solishtirganda tejamkorroq usuldir. Chunki qazib olinadigan yoqilg'ilar yaqin kelajakda tugashi mumkin va ko'plab jiddiy ekologik muammolarni keltirib chiqaradi, vodorod, yangi qayta tiklanadigan va ifloslantiruvchi energiyaning o’rnini egallash uchun istiqbolli nomzod sifatida qaraladi.

ADABIYOTLAR TAHLILI VA METODOLOGIYA

Qaytarilish va oksidlanish reaktsiyalari bitta zarracha yuzasida sodir bo‘lishi kerak va bir xil reaktor hajmida hosil bo'lgan vodorod va kislorodni darhol keyin ajratish kerak. Geterogen nanofotokatalitik katalizatorlar yordamida vodorod ishlab chiqarish bugungi kunda butun dunyo bo‘ylab tobora ko‘proq tadqiqot nuqtasiga aylanmoqda. Seolitlar aluminosilikatlar bo‘lib, ularning kristall tuzilishi qat’iy muntazam o‘lchamdagi kanallar va kataklarni belgilaydi. Ushbu bo‘sh kristalli bo‘shliqlar nanometr yoki subnanometr uzunlikdagi shkalada bo‘lib, mikroporlar deb ataladi. Qattiq ramka tomonidan yaratilgan bu teshiklarning ichki bo‘shliqlarida fotoaktiv mehmonni joylashtirish mumkin. Suvni fotolizi imkoniyati ko'plab tadqiqotchilar tomonidan o‘rganilgan bo‘lsada, foydali usul endigina ishlab chiqilmoqda. Suvni parchalash uchun Gibbsning erkin energiyasi 273kJ/mol yoki 1,23 eV bo‘lishi kerak. Suv ko‘rinadigan yorug‘lik uchun shaffof bo‘lgani uchun uni to‘g‘ridan-to‘g‘ri parchalash mumkin emas, faqat to‘lqin uzunligi 190 nm dan qisqa bo‘lgan nurlanish ta’sirida parchalanadi.[1]

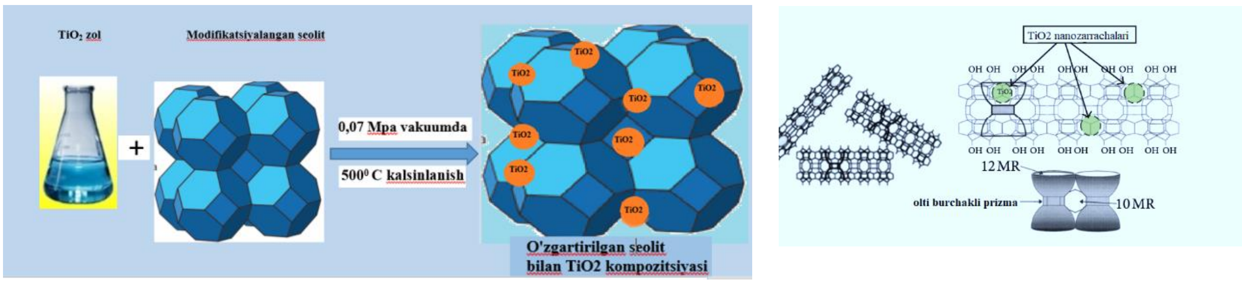
NATIJALAR

Sintetik seolit olishda SiO_2 manbasi sifatida Na_2SiO_3 tuzining eritmasidan, Al_2O_3 manbasi sifatida esa $NaAlO_2$ dan foydalanildi. Sintez jarayonida quruq holdagi $NaAlO_2$ - tuziga NaOH ning 2M eritmasi qo‘shildi hamda 40°C haroratda, 30 daqiqa davomida magnitli aralashtirgich yordamida aralashtirilib, bir jinsli kolloid suspenziyasi olindi. Olingan kolloid suspenziyaga Na_2SiO_3 ning suvli eritmasi qo‘shildi va eritma termostatga joylashtirilib, 2 soat davomida aralashtirildi. hosil qilingan gel distillangan suvda bir necha bor yuvildi hamda quritish shkafida 100°C haroratda 4 soat davomida quritildi. Seolit LTA olish uchun eng yaxshi tajriba sharoitlari quyidagilar edi: 3 mol·l $^{-1}$ NaOH eritmalari, 3 g natriy aluminat, yadrolanish uchun 3 soat va kristallanish uchun 24 soat davomida amalga oshirildi. Olingan seolitning fizik kimyoviy hossalari o‘rganildi[5].

Hozirgi sintezda quyidagi kimyoviy moddalar ishlatilgan; seolit LTA, TiO_2 (kimyoviy toza), titan(IV) oksid (Jiangxi, Xitoy), izopropanol (Jiangxi, Xitoy), etanol (Elxolding). Barcha kimyoviy moddalar keyingi tozalashsiz ishlatilgan.

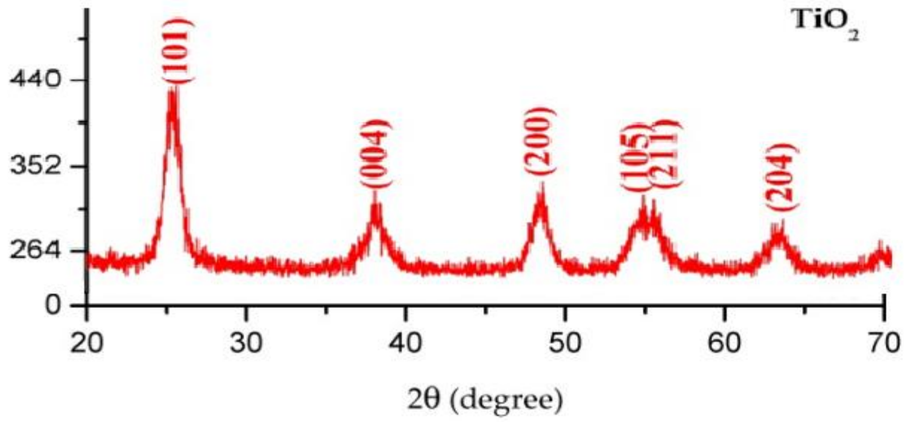
Ushbu kompozit metalloseolitlarni sintez qilish uchun asosiy material sifatida seolit-LTA (Si / Al = 2,2) ishlatiladi. Besh gramm sintez qilib olingan seolit-LTA olindi va unga 1,817 g titan(IV) oksid qo'shildi. Bu aralashma bir xil holga keltirildi va 500^{0}C da 1 soat davomida kalsinlandi. Keyin quritilgan kalsinlangan massa sovutilib keyin mikserda bir xil holatga keltirildi.

Izopropanolda erigan titan izopropoksid yordamida seolit-LTA asosidagi fotokatalitik material sintezi. Besh gramm sintez qilib olingan seolit-LTA olindi va unga 40 ml izopropanolda erigan 1,817 g titan(IV) oksidning izopropanoldagi eritmasi tomchilab qo‘shildi. Bu aralashma gomogen sistema hosil qilish uchun yaxshilab bir xil holatga keltirildi va keyin izopropanol 70-90^{0}C da bug‘landi. Gomogenlashtirilgan aralashma pechda 500^{0}C da 1 soat davomida kalsinlanadi. Sovutgandan so‘ng, kalsinlangan qattiq birikma ikki marta 100 ml distillangan suvda yuvildi va uning pH=6,5 ga keltirildi. Nanozarrachalarni tayyorlash uchun seolitning mikrog’ovak tuzilishiga fotokatalizatorlarni kiritish ularning fotokatalitik faolligini va fotobarqarorligini yaxshilashga urinishdir. Kichik nanozarralar sirt maydoni, sirt morfologiyasi va sirt nuqsonlari paydo bo‘lishining o‘zgarishi tufayli ommaviy materiallarga nisbatan yuqori fotokatalitik faollikni ko‘rsatadi[4]. Ushbu tadqiqotda turli o‘lchamdagi TiO_2 nanozarralarini tayyorlash uchun seolitlarning mikrog‘ovaklari qolip sifatida ishlatilgan (1-rasm).

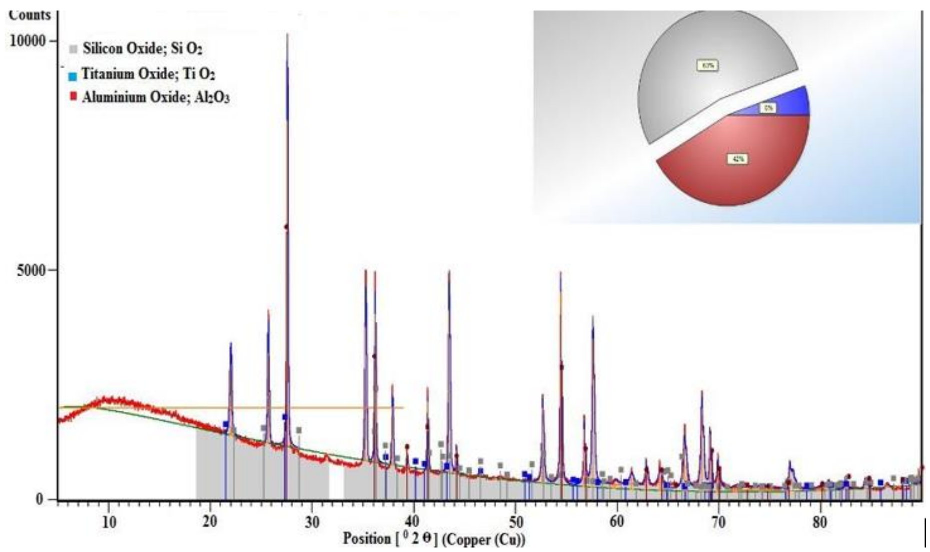


1-rasm. TiO_2 nanozarrachalarning seolit LTA bilan hosil qilgan nanokompozit birikmasi.

Sintezlangan fotokatalizatorning rentgen nurlari diffraktsiyasi tadqiqotlari seolitda TiO_2 fazasining ko'rinishini aniqlash va katalizatorni tayyorlash jarayonida seolitning kristalliligiga har qanday ta'sirni baholash uchun o'tkazildi. Sintezlangan materiallarning rentgen nurlanishini qayd qilish uchun Pananalytical Empyran rentgen difraktometrida (XRD) o'rganildi. XRD da difraktogrammalarni olish uchun CuKα – nurlanish (β-filtr, Cu, 1,5406 A^0 tok rejimi va trubkaga beriladigan kuchlanish mos ravishda 30 mA va 30 kV) va detektorning $0,02^0$ qadam bilan 4 grad/min aylanishning doimiy tezligida (bir-biriga mosligi ω/2 θ) qo'llanildi, skanerlash burchagi esa 0^0 dan 90^0 gacha o'zgartirildi. Tajribalarni qayd etishda aylanuvchi kamera qo'llanilgan bo'lib, uning aylanish tezligi 30 ayl/min ni tashkil etdi. Sintezlangan materiallar uchun d-oraliq qiymatlari seolit LTA va TiO_2 ning eng qizg'in cho'qqilarining d-oraliq qiymatlari bilan taqqoslanadi. Bundan tashqari sintez qilingan namunada titan oksidining turli ko'rishdagi anataz va rutil holatlari ham aks etishi aniqlandi. Bu ishda titan oksidlarini aralashmasidan foydanildi. XRD namunasi 2,3-rasmlarda keltirilgan[5].

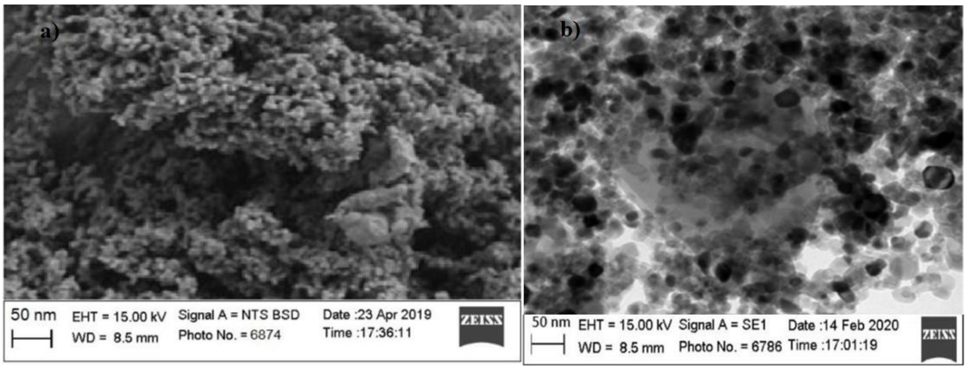


2-rasm. TiO_2 nanozarrachasining fazaviy tarkibi



3-rasm. Seolit LTA ning TiO_2 bilan hosil qilingan nanofotokatalizatorning fazaviy tarkibi

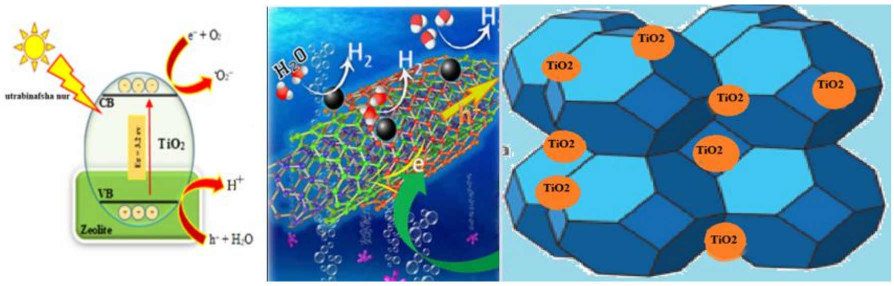
SEM EVO MA 10 (Carl Zeiss) skanerlovchi elektron mikroskopida energodispers rentgen spektrometr bilan jihozlangan (EDS Aztec Energya Adyanted X-Act, Oxford Instruments) qurilma yordamida, skanerlovchi elektron mikroskopiya usulida o‘rganildi; kuchlanish *1 kV* gacha oshirildi (x 200 000 gacha oshirilish), aks ettiruvchi detektor (SE2) va teskari elektron oqim (ESB) (4- rasm).



4-rasm. a) seolit LTA, b) seolit LTA bilan TiO_2 hosil qilgan kompozision birikmasining SEM da olingan tasviri.

MUHOKAMALAR

Seolitlarda zaryad o'tkazish (CT) va eT energiyani saqlash uchun zaryadni ajratishdan foydalangan holda real foydalanish, shuningdek, ushbu toifadagi reaktsiyalarga asosiy qiziqish tufayli katta e'tiborni jalb qildi. Seolitlar energiyani isrof qiluvchi orqaga elektron uzatishni (BeT) oldini olish, shuningdek, fotokimyoviy ravishda hosil bo'lgan oksidlanish-qaytarilish turlarini tinchlantirish orqali zaryadni ajratishga yordam berishda isbotlangan foydali xususiyatlarga ega[13]. Nanozarrachalarni tayyorlash uchun seolitning mikrog‘ovak tuzilishiga fotokatalizatorlarni kiritish ularning fotokatalitik faolligini va fotobarqarorligining o‘zgarishiga olib keldi. Kichik nanozarralar sirt maydoni, sirt morfologiyasi va sirt nuqsonlari paydo bo'lishining o'zgarishi tufayli seolit bilan hosil qilmagan kompozision materiallarga nisbatan yuqori fotokatalitik faollikni ko‘rsatdi[4]. Nanofotokatalizator sifatida CdS bilan seolit-LTA ning kompozision birikmalarining fotokatalitik faolligini tekshirilganda vodorodni ajralish tezligi yuqoriligi, lekin fotokorroziyaga barqarorligi kamligi aniqlandi. Shuning uchun kompozision birikma uchun TiO_2 dan foydanildi. Chunki titan oksidining fotokatalitik barqarorligi yuqori ekanligi aniqlangan. Ushbu tadqiqotda turli o‘lchamdagi TiO_2 nanozarralarini tayyorlash uchun seolitlarning mikrog'ovaklari qolip sifatida ishlatildi. Seolitning sirt fazasidagi TiO_2 nanozarralar suvning fotokatalitik parchalanishi uchun katalizator vazifasini bajardi. Suvning fotolizi bu parchalanish reaktsiyasini engillashtirish uchun yorug‘lik energiyasi (sun’iy yoki quyosh) va ba’zi turdagi fotokatalizatorlar yordamida suvning H_2 va O_2 ga to‘g‘ridan-to‘g‘ri parchalanishini anglatadi [10] (5-rasm).



5-rasm. Seolit LTA bilan TiO_2 kompozitsion hosil qilgan fotokatalizator yuzasida suvning fotokatalitik parchalanish mexanizmi.

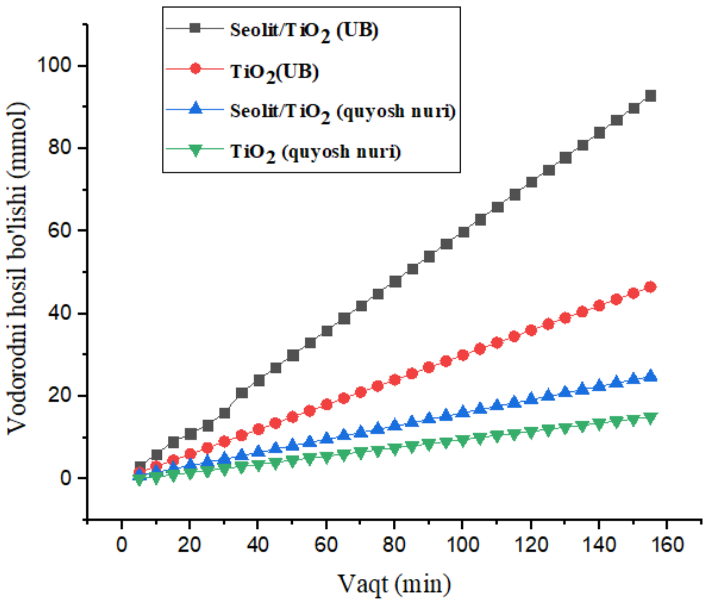
Suvni bo‘lish uchun Gibbsning erkin energiyasi 273kJ/mol yoki 1,23 eV bo‘lishi kerak. Reaksiya quyidagicha ifodalanadi:

$2H_2O \rightarrow 2H_2 + O_2$ (1)

$2H_2O + 4h^+ \rightarrow O_2 + 4H^+$ (2)

$2H^+ + 2e^- \rightarrow H_2$ (3)

Seolit A asosida TiO_2 bilan sintez qilingan fotokatalizatorni vaqt birligi ichida suvning parchalanishidan vodorod hosil bo’lish tezligi, TiO_2 katalizatoriga nisbatan samaraliroq ekanligi aniqlandi. Vodorodning ajralish tezligi ultrabinafsha nurning intensivligiga ham bog’liqligi kuzatildi. Ko’rinadigan nurda olib borilganda vodorodning ajralish tezligi kamaydi. Seolit LTA bilan muvofiqlashtirishga ega bo'lgan bu katalizatorlar singdirish usuli bilan tayyorlangan titan oksidi katalizatorlari, shuningdek, katta hajmdagi TiO_2 kukunli katalizatorlari bilan solishtirganda yuqori, xarakterli fotokatalitik reaktivlikni ko'rsatdi (6-rasm).



6-rasm. Seolit A asosida TiO_2 bilan sintez qilingan fotokatalizator bilan TiO_2 fotokatalizatorining vodorodni hosil bo’lish tezligi.

XULOSA

Tajribalarda TiO_2 seolit A ga yuklangan nanozarrachalar eng yuqori samaradorlikni namoyish etdi. Katta o'ziga xos sirt maydoni tufayli tabiiy seolit LTA TiO_2 uchun optimal tashuvchidir. TiO_2 zarralari seolit LTA yuzasida nanomiqyosda bir xil tarqaldi. Natijalar zeolitlarda qo'llab-quvvatlanganda shunga o'xshash TiO_2 fazalarining fotoaktivligining sezilarli o'zgarishini ta'kidlaydi.

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