

1 :

1992 Mobil M41S 20-
100 가 [1].
source (TEOS, TMOS, Ludox, Carbosil, sodium silicate)
(micelle) (supramolecular
assembly) (hydrolysis /
condensation sol-gel process) (lamella, MCM -50),
(hexagonal, MCM -41), (cubic, MCM -48) [1-2].
가
(
가
/
가
가
(leaching)
가 [3]
block copolymer (template)
oxide, sulfide, phosphate, metal
가 [4],
review [2-4].
guest
nanoelectronics 가
(host)
[5,6] ,
[7,8] 가
/
/
amino, thiol,
epoxide (organic functional group) grafting
[9-11], TEOS(tetraethyl orthosilicate)
vinyl, phenyl, mercaptopropyl aminopropyl
[12-14].

가, spacer

ligand complex 가

2 tethering

Inagaki[15], Stein[16], and Ozin[17] 1999 1,2-

bis(triethoxysilyl)ethane/ ethene trialkoxysilyl organic bridge(C-

C) organosilane ,

(hydrolysis) (polymerization)

/

Ethene, methylene, benzene, vinylene,

thiophene, ferrocene /

가 가 /

M41S ,

/ (hydrophilicity/hydrophobicity) 가 ,

/

1990 ,

MCM -41 .

MCM -41, -48, HMS, SBA -1

recipe

(pH= 13) MCM -41 MCM -48 . MCM -41

1 D hexagonal , 가 3-4 nm , 가

가 mesitylene swelling agent

. Mesitylene (1,3,5, trimethylbenzene)

chain micelle . Swelling

. MCM -48

3

. 가 MCM -41 . HMS

가

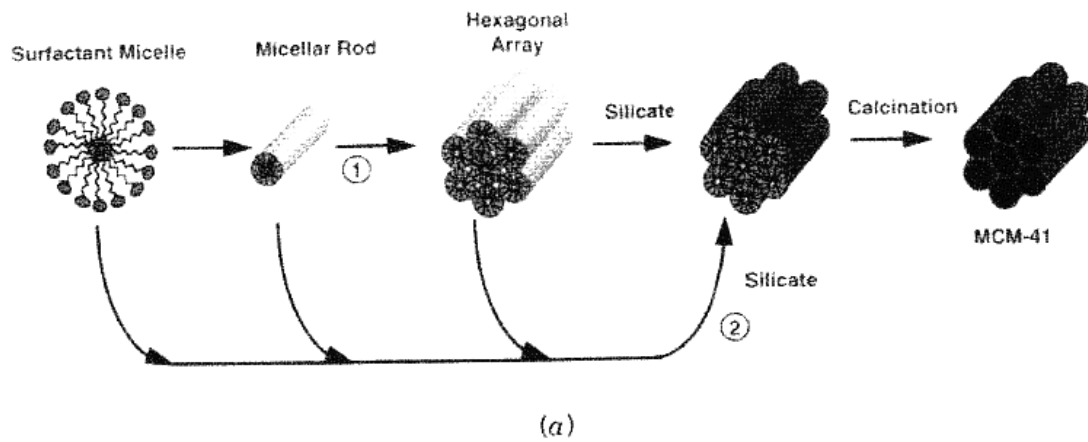


Figure 1. Mobil S^+I^- mechanistic routes for the formation of the hexagonal MCM-41: route (1), liquid crystal phase initiated, and route (2), silicate anion initiated.

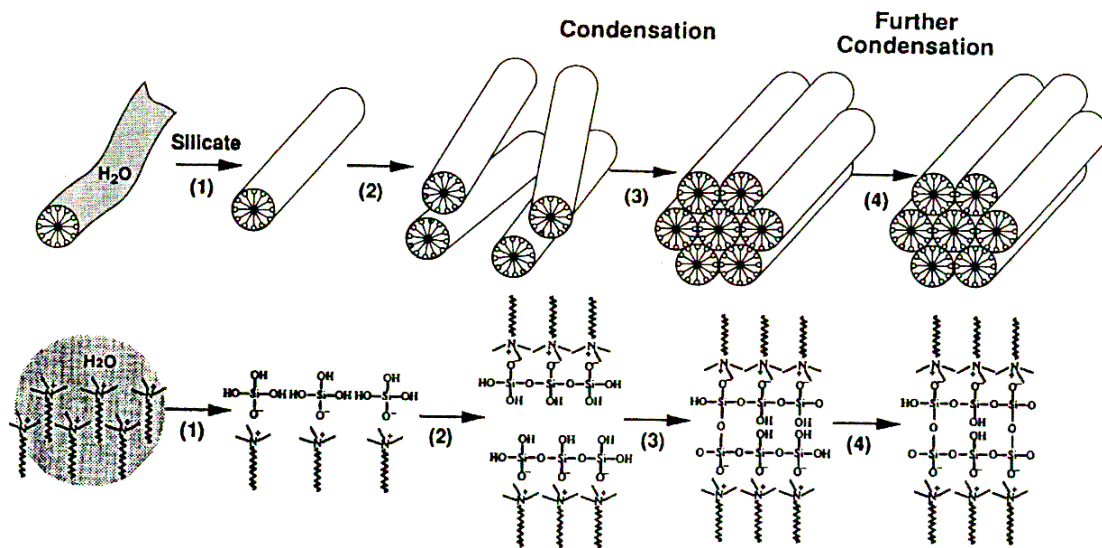


Figure 2. Mechanism for the S^+I^- formation of MCM-41 proposed by Davis et al. (Reprinted with permission from M. E. Davis, C.-Y. Chen, S. L. Burkett, and R. F. Lobo, in *Better Ceramics Through Chemistry*, MRS Symposium Proceedings, Vol. 346, Pittsburgh, PA, 1994, p. 831. Copyright 1994, Materials Research Society)

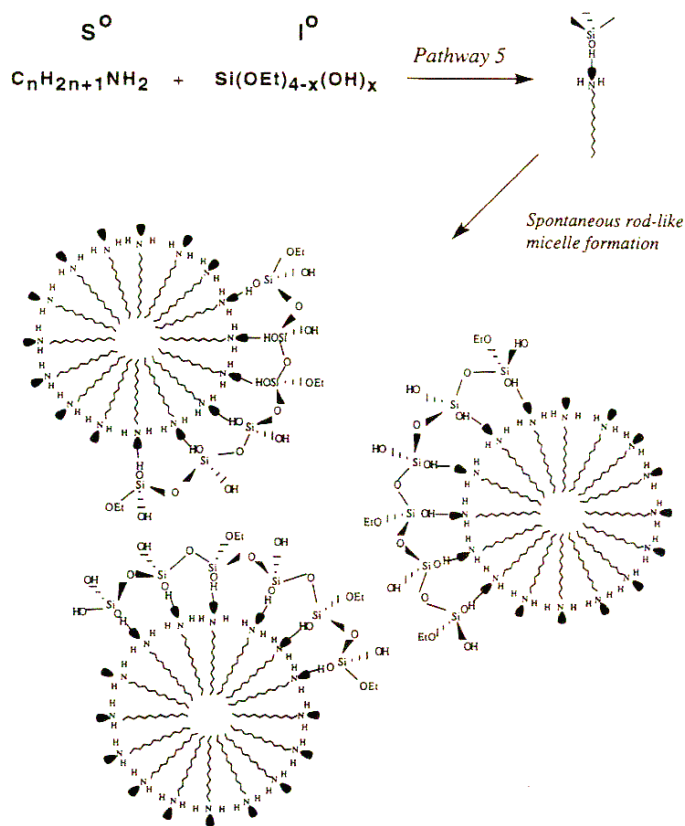


Figure 3. Neutral S I templating mechanism to mesoporous molecular sieves.

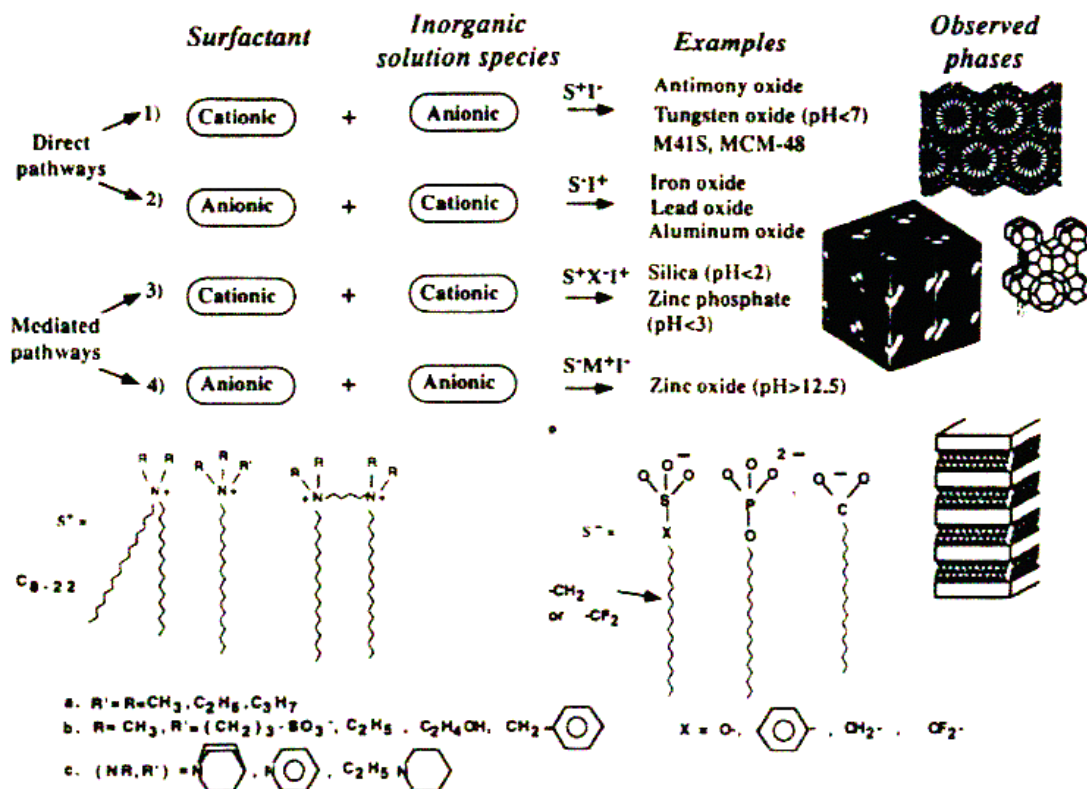


Figure 4. Schematic representation of the four complementary electrostatic templation pathways to ordered mesostructures. (Reprinted with permission from Q. Huo et al., Nature 368, 317 (1994). Copyright 1994, Macmillan Magazines Ltd.)

가
 textual mesopore가 ,
 가
 SBA -15 ethylene oxide()-propylene oxide() block
 copolymer (pH=1 -2) ,
 5 -30 nm (3 -6 nm)
 hydrothermal stability가 , silanol
 가 .

(MCM -41)

-Sodium silicate solution

NaOH 3.882g H₂O 97.046g .

HS -40 Ludox source 가 , 60 .

-Surfactant solution

(NH₄)₂O 0.963g H₂O 100.612g ,

cetyltrimethylammonium bromide (CTABr) 18.196g 60

. SiO₂ /0.48 NaOH/ 0.246 C₁₆TMACI /0.082 (NH₄)₂O/59.3 H₂O

1 가 105 가 , 24

acetic acid 1M, 0.6M, 0.25M pH 11 3 . 4 ,

100 2 /min 220 가 , 3 holding, 1.5 /min 550 가
 4 holding .

(swelled MCM -41)

NH₄OH C12 C16 surfactant surfactant
 solution HS -40 Cab -O -Sil M5 NaOH silica
 solution 1 . SiO₂ /0.542 NaOH/ 0.116 C₁₆TMACI /0.025

C₁₂TMABr/ 0.5 or 0.75 mesitylene /30.3 H₂O .

MCM -41 .

(MCM -48)

1. 9 wt % sodium silicate

NaOH 51.68 g 1338.06 g 70⁰C . NaOH

Ludox HS40 410.13 g 가. 343 ~ 353K .

30 가 .

2. MCM -48

CTABr 42.18 g LE-4 7.33 g 571.57 g 100 °C
 sodium silicate 450 g 가 , 1
 373K 373K 48
 30wt% 40.48 g 가
 30 1 가 373K 373K
 48 filtering

(HMS)

Ethanol TEOS dodecylamine (DDA) HCl
 가 . SiO₂ : DDA : ethanol : HCl : H₂O = 1 : 0.2 : 9 : 0.02 : 160
 298K 24 Filtering ethanol 2
 washing 373K 1 823K 5

(SBA -15)

Triblock copolymer P123 HCl H₂O 가
 stirring 288K 1 aging TEOS 가
 (P123 : HCl : H₂O : TEOS = 10 g : 0.6 mol : 20 mol : 0.1 mol) 10~20 stirring
 288K 24 aging 373K 24 가 filtering
 ethanol 383K 1 823K 5

packing parameter, $g = V/a_0l$

g

V

a₀

head group

$g = 1/3$

cubic(*Pm3n*), 1/2 hexagonal(*p6m*), 1/2 -2/3 cubic(*Ia3d*), 1 lamellar
 phase가 g 가
 (curvature)가 cubic lamellar 가 , V a₀
 g

(18,19).

가,

counter ion

g factor

가

MSU

MSU

polyethylene oxides (PEO)

(20).

PEO, wormhole, NaF 가 2 (21). MSU 가 HPLC (22). Lyotropic liquid crystal templating surfactant templating 가 (23,24). (50 wt %) liquid crystal , TMOS sol-gel (cast) octaethylene glycol monododecyl/hexadecyl ether cetyltrimethylammonium bromide, amphiphilic block copolymer liquid crystal surfactant templating oligomer charge matching 가 , solid mold template (template) latex (polystyrene bead) sphere templating latex sol-gel LBL (layer by layer) hollow sphere PMO (periodic ordered mesoporous organosilica) ethene ethane group poly(trialkoxysilyl)organic precursor . 1 BTME(1,2 bis(trimethoxysilyl) ethane) : 0.91 CTMACI (cetyltrimethylammonium chloride) : 2.28 NaOH : 336 H₂O cubic - decaoctahedral [25]. SBA -15 block copolymer [26], Zhu [27] lyotropic liquid crystal templating SBA -15 hydrid

가
 , 가
 chromatography 가 가
 가 - 가
 가
 hydrothermal ,
 가 .
 가 ,
 . SBA -15
 hydrothermal
 가
 ,
 , 가 , ZSM -5 TS-1(Titanium silicalite -
 1)
 가 [28,29].

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