

1.

가

가

(bone cement)

10~30

가

가

1

(, implant)

1 PMMA

가



1972 ()
 1979 (Ph.D.)
 1980 Univ. of Arizona, Post - Doc
 1981 Univ. of Michigan, Post - Doc
 1985 IBM
 1986
 1979 KIST



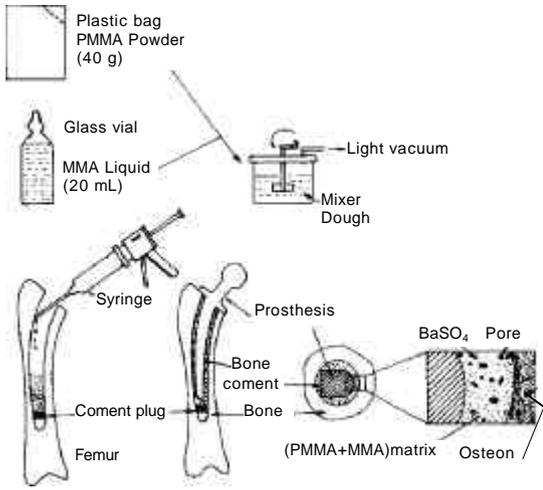
1997
 2001 ()
 2001



1983 ()
 1985 ()
 1993
 (Ph.D.)
 1995 Caltech, Post - Doc
 1996
 1985 KIST

Bone Cements for Surgical Applications

(Hye Jung Im, Kwang - Duk Ahn, and Dong Keun Han, Biomaterials Research Center, KIST, P.O. Box 131, Cheongryang, Seoul 130 - 650, Korea)



1. PMMA

2.

2.1 Poly(methyl methacrylate) (PMMA)

PMMA 1960, Sir John Charnley

10% 가 가

3

가

가,

PMMA Palacos R (Merck),
Surgical Simplex P (Howmedica), CMW
Endurance (Depuy), Zimmer Os -
teobondTM (Zimmer), Sulfix - 60 (

1. PMMA

3,4

Kind	Powder				Cement				Tensile Strength (MPa)
	M _v	M _n	M _w	M _w /M _n	M _v	M _n	M _w	M _w /M _n	
CMW	1.0 × 10 ⁵				1.45 × 10 ⁵				39.1
CMW		5.46 × 10 ⁴	1.43 × 10 ⁵						
CMW	1.14 × 10 ⁵	4.3 × 10 ⁴	1.06 × 10 ⁵	2.5	1.95 × 10 ⁵	4.7 × 10 ⁴	1.43 × 10 ⁵	3.0	44.7
Palacos R	4.59 × 10 ⁵				3.88 × 10 ⁵				51.4
Sulfix - 6	1.19 × 10 ⁵				1.31 × 10 ⁵				50.7
Simplex p	8.90 × 10 ⁴				1.19 × 10 ⁵				
Simplex P	1.95 × 10 ⁵	4.4 × 10 ⁴	1.98 × 10 ⁵	4.49	2.03 × 10 ⁵	5.1 × 10 ⁴	2.42 × 10 ⁵	4.78	50.1
Kallodent			5.4 × 10 ⁵	2.5			7.5 × 10 ⁵	3.0	
Stellon			7.2 × 10 ⁵	2.5			9.0 × 10 ⁵	3.3	
Rostal	4.74 × 10 ⁵	1.09 × 10 ⁵	3.24 × 10 ⁵	2.5	5.77 × 10 ⁵	1.3 × 10 ⁵	3.16 × 10 ⁵	2.5	

Sulzer), Duracem 3 (SulzerMedica)
 Boneloc (Polymers Reconstructive
 A/S)

hydroquinone (HQ)
 가 X - ray
 barium sulfate (BaSO₄)
 (2).

2.1.1
 Methyl methacrylate (MMA) PMMA

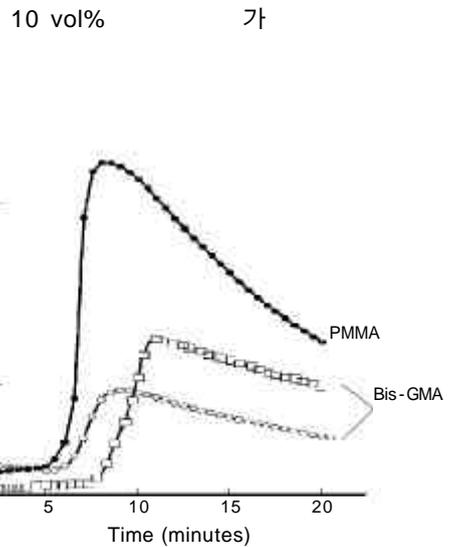
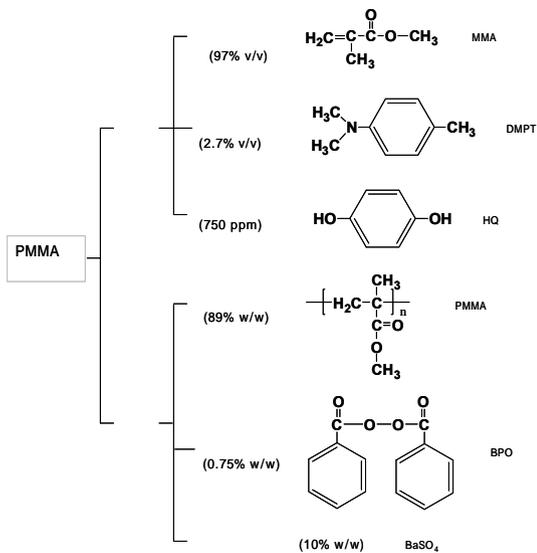
2.1.2

가 . UV
 가 가
 PMMA 가 1 5 15 3 10
 MMA 가
 benzoyl peroxide (BPO)가

. PMMA
 BPO N,N - 37~80 , 110~124
 dimethyl - *r*-toluidine (DMPT) 가 (3).^{6,7} 56~60
 가 BPO PMMA
 PMMA (: 270,000~
 1,200,000)

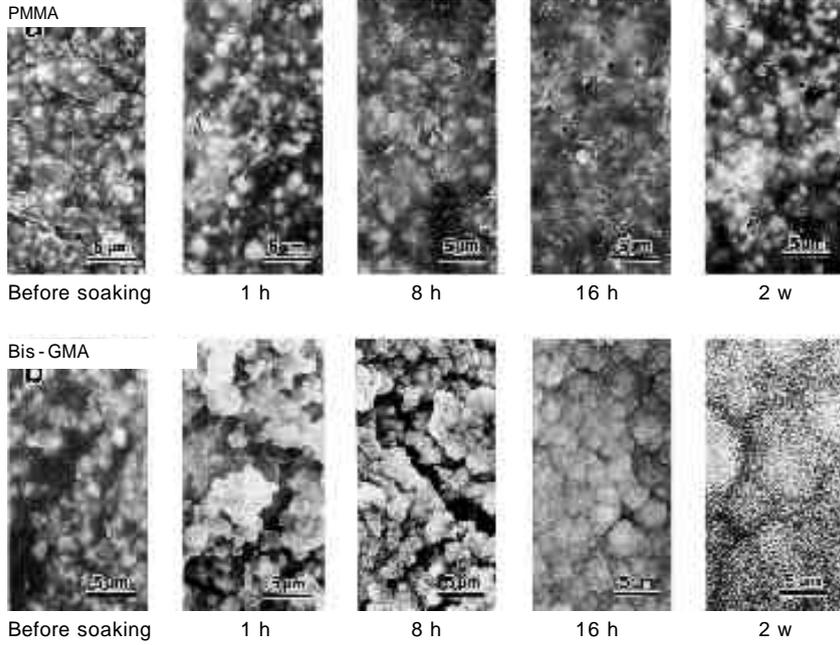
가 ,⁸ MMA
 PMMA

PMMA



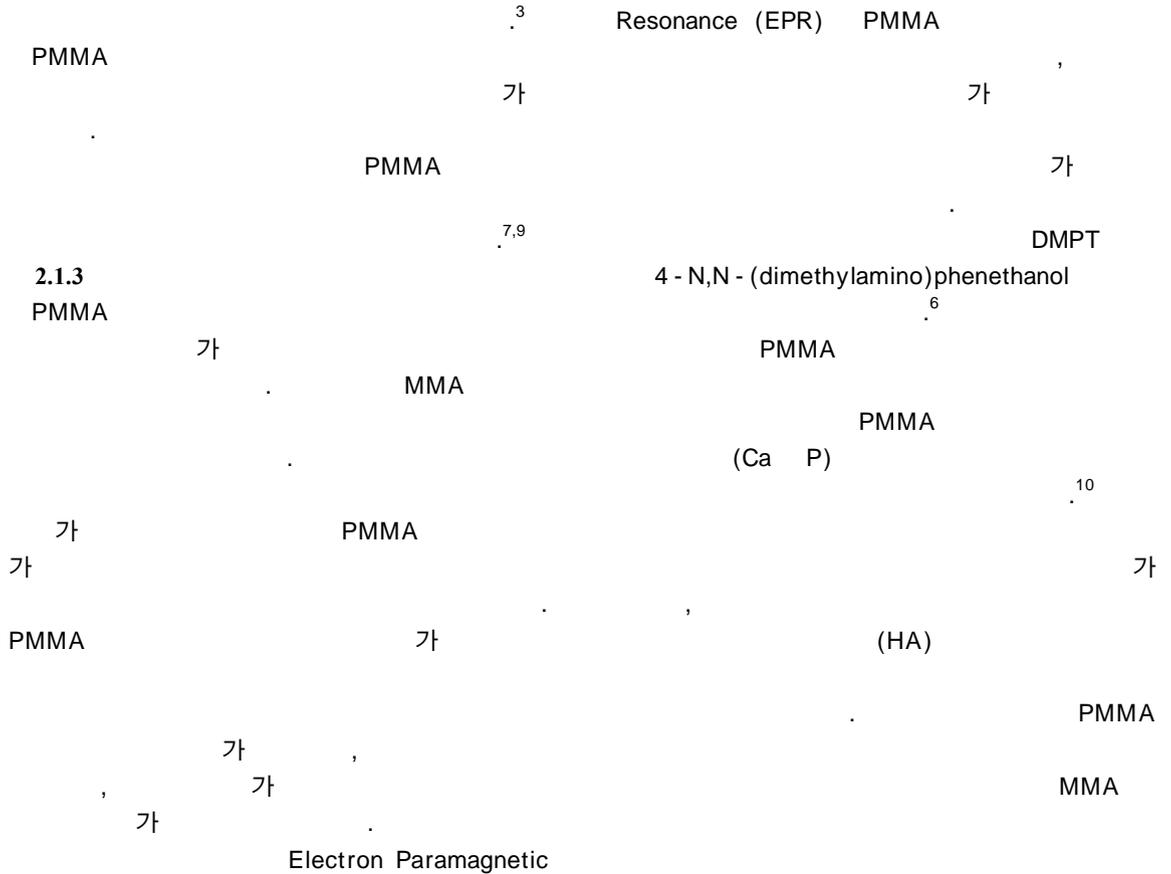
3. PMMA Bis - GMA

2. PMMA



4. PMMA Bis-GMA

11



가

80

가

(4).¹¹ PMMA
gentamicin clindamycin

pH가

2

가

3

2.2.2

12

2.2

가

2.2.1

(calcium phosphate) 1976
가 PMMA

가

13

가

osteocalcin

가

mRNA

가

가

2.

3

Cement Type	Active Ingredients	Modifier Added	Compressive Strength (MPa)	Tensile Strength (MPa)
PHA	TTCP+DCP	-	34±4	-
PHA	TTCP+DCP	PHA	31±7	-
PHA	TTCP+DCP	PHA/FA	5-28	-
PHA	TTCP+DCP	PHA	10-42	-
PHA	TTCP+DCP	-	36	-
PHA	TTCP+DCP	-	0-51	-
PHA	TTCP+DCPD	-	31±5	-
PHA	TTCP+DCPD	-	9±3	-
OCP	a-TCP+DCPD	-	17±3	-
OCP	a-TCP+DCP	PHA	50±5	8±1
?	a-TCP	Collagen	15±5	-
CDHA	a-TCP	PHA	70±5	11±2
DCPD	b-TCP+MCPM	-	-	0.1±1.1
DCPD	b-TCP+MCPM	plaster	-	0.9±3.2
PHA	DCPD+CaCO ₃	b-TCP	-	0.6±1.7
DCPD	a-TCP+citric acid	-	110±20	-
DCPD	a-TCP+citric acid	-	90-120	-
?	a-TCP+DCP+b-TCP	-	18-35	-
CDHA	MCPM+TTCP+Ca(OH) ₂	-	50-90	-
OCP	MCPM+a-TCP	-	12±2	3±1
CDHA	MCPM+CaO	PHA	6±1	2±1
COP	MCPM+CaO	PHA	6±1	1.5±0.5
OCP	a-TCP+DCPD	PHA	6±1	1.2±0.3
DCPD	TTCP+MCPM	-	4±1	-

가

가

가

가 가

polyphosphate가

가 DNA

가

가

2.3 Bis - GMA

1963 Bowen

bisphenol - A - glycidylmetha - crylate (Bis - GMA)

Bis - GMA

PMMA

가 가

10

Bis - GMA

PMMA

가

γ -MPS¹¹
 가 . γ Bis - GMA
 -MPS 0.2 wt% , Bis - GMA
 가 가 3 4 3MA 4MA
 Bis - GMA 가 , 가,
 0.1~0.2 wt%¹⁶
 Bis - GMA
 3.
 AW - GC가
 가 3.1 3가
 AW - GC HA²¹ Polypropylene (PP) spatula bowl
 HA b - TCP 1 - 15
 Bis - GMA¹⁷ 4 가 1~2 Hz
 dexamethasone 45~120 2
 가 30~180 2,300~4,000
 가 rpm
¹⁸ phenothiazine 3
 가 Bis - GMA 가
 가 가¹⁹ Bis - GMA
 가 가^{14,20}
 Bis - GMA Bis - GMA
 DMA가 TEG -
 가 가
 (4). 가 MITAB 가
 가 kPa 30~75 PP spatula
 TEGDMA PMMA

Mixing System	Reduced Pressure (kPa)	Porosity (%)		Compressive Strength (MPa)		Flexural Modulus (GPa)		Flexural Strength (MPa)	
		\bar{x}	σ	\bar{x}	σ	\bar{x}	σ	\bar{x}	σ
Howmedica Mix Kit I [®]	Atmospheric pressure	16.4	0.78	65.79	7.80	2.11	0.10	54.67	6.00
Zimmer Osteobond [®]	- 39	10.3	0.81	71.71	5.22	2.27	0.20	59.78	4.20
Summit LoVac [®] Bowl	- 39	9.86	1.24	79.29	8.90	2.65	0.10	69.17	3.50
Cemvac [®]	- 69	4.37	1.55	74.14	3.91	2.47	0.18	60.20	7.16
Summit HiVac [®] Syringe	- 72	3.17	1.54	79.18	4.33	2.60	0.10	70.10	4.70
Summit HiVac [®] Syringe	- 86	1.70	0.76	74.52	5.75	2.54	0.06	65.90	5.00
Mitab Optimac [®]	- 86	1.44	0.24	81.04	12.17	2.59	0.25	72.69	9.66

Optivac
가

3.2

가

micro - cracking

1

가

2

(- 30 kPa)

가

가

1, 2

3

가

2

(- 70 kPa)

(5).^{22,23} 가

가

PMMA

가

가

1) 3

가

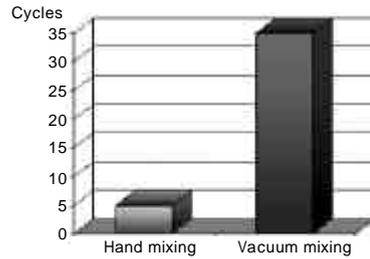
2)

가

3) 1, 2

가

Increased fatigue strength



Hand mixing



Low vacuum mixing



High vacuum mixing

5.

²³

가

- 72 kPa

²⁴

가

가

25

26

27

가

1.

가

가

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4.

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