

Content

CONTENT	1
1 INTRODUCTION AND AIMS	3
1.1 GLOBAL WARMING AND CO ₂ EMISSIONS	3
1.2 POWER PLANT AND GAS SEPARATION CONCEPTS	4
1.3 OBJECT AND OUTLINE OF THIS THESIS	5
2 THEORETICAL BACKGROUND	7
2.1 INORGANIC GAS SEPARATION MEMBRANES	7
2.1.1 Dense metallic and ceramic membranes	8
2.1.2 Microporous inorganic membranes.....	13
2.2 ZEOLITE MEMBRANES	14
2.2.1 Zeolite membrane material synthesis	15
2.2.2 Zeolite membrane preparation methods	16
2.2.3 State of the art zeolite membranes.....	20
2.2.4 Selection of zeolite types.....	21
2.3 SOL-GEL DERIVED MEMBRANES	24
2.3.1 Sol-Gel chemistry	24
2.3.2 Sol-Gel membrane preparation methods	26
2.3.3 State of the art Sol-Gel derived membranes	27
2.3.4 Selection of Sol-Gel derived membrane material	29
2.4 MICROPOROUS MEMBRANE CHARACTERISATION METHODS	31
2.4.1 Morphology	31
2.4.2 Mass transport.....	32
3 EXPERIMENTAL	37
3.1 SUPPORTS AND INTERMEDIATE LAYERS	37
3.1.1 Support formation.....	37
3.1.2 Intermediate layer material characterisation and layer formation	38
3.2 SYNTHESIS OF ZEOLITE MATERIAL AND MEMBRANE PREPARATION	39
3.2.1 Hydrothermal zeolite syntheses	39
3.2.2 SDA removal from dodecasil-1H by post synthesis treatments	40
3.2.3 Dodecasil-1H layer formation.....	41
3.3 SOL-GEL DERIVED TiO ₂ , ZrO ₂ AND BINARY OXIDE MEMBRANES	42
3.3.1 Polymeric TiO ₂ , ZrO ₂ and binary oxide sol synthesis.....	42
3.3.2 Drying and sintering of TiO ₂ , ZrO ₂ and binary oxide bulk material	44
3.3.3 Microporous TiO ₂ , ZrO ₂ and binary oxide membrane preparation	44
3.4 CHARACTERISATION FOR MICROPOROUS MATERIALS AND MEMBRANES	45
3.4.1 Microporous material characterisation.....	45
3.4.2 Microporous membrane characterisation	47
4 RESULTS AND DISCUSSION	50
4.1 SUPPORTS AND INTERMEDIATE LAYERS	50

4.2	ZEOLITE MATERIALS AND LAYERS	53
4.2.1	<i>Deca-dodecasil-3R synthesis</i>	53
4.2.2	<i>Structure directing agent free Dodecasil-1H synthesis</i>	54
4.2.3	<i>Dodecasil-1H layer characterisation</i>	66
4.3	SOL-GEL DERIVED MEMBRANES.....	70
4.3.1	<i>Polymeric sol characterisation</i>	70
4.3.2	<i>Microstructure properties of membrane material</i>	75
4.3.3	<i>Sol-Gel derived membrane characterisation</i>	96
4.3.4	<i>Gas permeation</i>	106
5	CONCLUSIONS AND RECOMMENDATIONS.....	110
6	REFERENCES.....	114