

CONTENTS

	Page
LIST OF TABLES	vii
LIST OF FIGURES	viii
LIST OF ABBREVIATIONS	xiii
LIST OF RADIOACTIVITY UNITS	xv
SUMMARY	xvi

CHAPTER 1

INTRODUCTION

1.1. General considerations	1
1.2. Chemistry, radiochemistry and nuclear chemistry of uranium	2
1.2.1. Chemistry of uranium	2
1.2.2. Radiochemistry and nuclear chemistry of uranium	3
1.3. Periodic Table and ²³⁵U-fission products	6
1.4. Radioactivity and specific activity of ²³⁵U-fission isotopes	7
1.5. Chemical processing for separation of some ²³⁵U-fission products	13
1.5.1. Radioiodine	19
1.5.2. Radioruthenium	23
1.5.3. Radiocesium	26
1.5.4. Radiomolybdenum	30
1.5.5. Radio-zirconium and -niobium	38
1.6. Some beneficial applications of ²³⁵U-fission products	42
1.6.1. Radioisotope generators	42
1.6.1.1. ¹³⁷ Cs/ ^{137m} Ba generators	44
1.6.1.2. ⁹⁹ Mo/ ^{99m} Tc generators	47
1.6.2. Sealed sources	51
1.6.3. Nuclear batteries	52
1.6.4. Miscellaneous applications	52

CHAPTER 2

EXPERIMENTAL

2.1. Chemicals and solutions	54
2.1.1. Chemicals	54
2.1.2. Solutions	55

	Page
2.2. Equipments	56
2.3. Preparation of 6-tungstocerate(IV), 6-WCe, gel matrix	57
2.4. Target preparation and irradiation	57
2.5. Target dissolution	58
2.6. Separation of radioiodine	61
2.6.1. Hot FP solution	61
2.6.2. Aged FP solution	61
2.7. Separation of radoruthenium	61
2.7.1. Aged FP solution	61
2.7.2. Hot FP solution	61
2.8. Separation of radiocesium	62
2.8.1. Aged FP solution	62
2.8.2. Hot FP solution	62
2.9. Separation of radiomolybdenum	63
2.10. Separation of radio-zirconium and –niobium	63
2.11. Radioisotope generators	64
2.11.1. $^{137}\text{Cs}/^{137\text{m}}\text{Ba}$ generator based on 6-WCe column	64
2.11.1.1. Batch distribution studies	64
2.11.1.2. Column preparation and loading with ^{137}Cs	65
2.11.1.3. $^{137\text{m}}\text{Ba}$ Elution	65
2.11.2. $^{99}\text{Mo}/^{99\text{m}}\text{Tc}$ generator based on alumina column	65
2.11.2.1. Column preparation and loading with ^{99}Mo	65
2.11.2.2. $^{99\text{m}}\text{Tc}$ Elution	66
2.11.3. $^{99}\text{Mo}/^{99\text{m}}\text{Tc}$ - $^{137}\text{Cs}/^{137\text{m}}\text{Ba}$ dual generator based on 6-WCe column	66
2.11.3.1. Column preparation and loading with ^{99}Mo and ^{137}Cs	66
2.11.3.2. $^{99\text{m}}\text{Tc}$ Elution	66
2.11.3.3. $^{137\text{m}}\text{Ba}$ Elution	66
2.12. Quality control investigations	67
2.12.1. Elution profiles of generator-produced radionuclides	67
2.12.2. Separation and elution yields	67
2.12.3. Recovery yield	68
2.12.4. Radionuclidic purity	68

	Page
2.12.4.1. Gamma-ray spectrometry	69
2.12.4.2. Radioactive decay curve	69
2.12.5. Radiochemical purity	70
2.12.5.1. Radiochemical purity of radioiodine	71
2.12.5.2. Radiochemical purity of ^{99m}Tc eluate	71
2.12.6. Chemical purity	71
2.12.6.1. Chemical purity of ^{137m}Ba and ^{99m}Tc eluates from the 6-WCe columns	71
2.12.6.1.1. Determination of tungsten by the thiocyanate method	72
2.12.6.1.2. Determination of cerium by the persulfate method	72
2.12.6.2. Chemical purity of ^{99m}Tc eluates from the alumina column	73
2.12.7. pH-value	73
 CHAPTER 3 RESULTS AND DISCUSSION	
3.1. Preparation of the fission-product feeding solutions	74
3.1.1. Sodium hydroxide digestion	74
3.1.2. Nitric acid treatment	74
3.1.3. Advantages of the alkali/acid dissolution process	75
3.2. Gamma-ray spectrometric analysis of FP feeding solutions	76
3.2.1. Hot FP feeding solution	76
3.2.2. Aged FP feeding solution	78
3.3. Separation of radioiodine	81
3.3.1. Separation of ^{131}I from the hot FP solution	82
3.3.1.1. Separation yield of ^{131}I	82
3.3.1.2. Recovery yield of ^{131}I	82
3.3.1.3. Radionuclidic purity of ^{131}I	82
3.3.1.4. Radiochemical purity of ^{131}I	85
3.3.1.5. pH-value of the ^{131}I -product solution	87
3.3.1.6. Radioactivity and radioactive concentration of the ^{131}I product-solution	87
3.3.2. Separation of ^{129}I from the aged FP solution	89
3.4. Separation of radoruthenium	91
3.4.1. Separation of ^{106}Ru from the aged FP solution	93
3.4.1.1. Separation yield of ^{106}Ru	93

	Page
3.7.4. Recovery yield of the $^{95}\text{Zr}/^{95}\text{Nb}$ couple	137
3.7.5. Radionuclidic purity of the $^{95}\text{Zr}/^{95}\text{Nb}$ couple	138
3.7.6. Radioactivity and radioactive concentration of the $^{95}\text{Zr}/^{95}\text{Nb}$ -product solution	138
3.8. Radioisotope generators	140
3.8.1. $^{137}\text{Cs}/^{137\text{m}}\text{Ba}$ generator system based on 6-WCe column	143
3.8.1.1. Preparation of the $^{137}\text{Cs}/^{137\text{m}}\text{Ba}$ generator	145
3.8.1.2. Quality control of $^{137\text{m}}\text{Ba}$ eluates	145
3.8.1.2.1. Elution performance of $^{137\text{m}}\text{Ba}$	145
3.8.1.2.1.1. Eluent selection and elution profiles of $^{137\text{m}}\text{Ba}$	145
3.8.1.2.1.2. Elution yield of $^{137\text{m}}\text{Ba}$	148
3.8.1.2.2. Radionuclidic purity of $^{137\text{m}}\text{Ba}$	151
3.8.1.2.3. Chemical purity of $^{137\text{m}}\text{Ba}$	154
3.8.1.2.4. pH-value of $^{137\text{m}}\text{Ba}$ eluates	154
3.8.1.2.5. Reproducibility of the $^{137}\text{Cs}/^{137\text{m}}\text{Ba}$ generator system	155
3.8.1.3. Advantages and applications of $^{137}\text{Cs}/^{137\text{m}}\text{Ba}$ generators	157
3.8.2. $^{99}\text{Mo}/^{99\text{m}}\text{Tc}$ generator based on alumina column	157
3.8.2.1. Loading of ^{99}Mo onto the alumina column	157
3.8.2.2. Conditioning of the alumina column for $^{99\text{m}}\text{Tc}$ elution	160
3.8.2.3. Quality control of $^{99\text{m}}\text{Tc}$ eluates	160
3.8.2.3.1. Elution performance of $^{99\text{m}}\text{Tc}$	160
3.8.2.3.1.1. Elution profiles of $^{99\text{m}}\text{Tc}$	164
3.8.2.3.1.2. Elution yield of $^{99\text{m}}\text{Tc}$	164
3.8.2.3.2. Radionuclidic purity of $^{99\text{m}}\text{Tc}$	164
3.8.2.3.3. Radiochemical purity of $^{99\text{m}}\text{Tc}$	167
3.8.2.3.4. Chemical purity of $^{99\text{m}}\text{Tc}$	167
3.8.2.3.5. pH-value of $^{99\text{m}}\text{Tc}$ eluates	167
3.8.2.3.6. Reproducibility of the $^{99}\text{Mo}/^{99\text{m}}\text{Tc}$ generator system	170
3.8.2.4. Advantages and applications of $^{99}\text{Mo}/^{99\text{m}}\text{Tc}$ generators	170
3.8.3. $^{99}\text{Mo}/^{99\text{m}}\text{Tc}$ - $^{137}\text{Cs}/^{137\text{m}}\text{Ba}$ dual generator system based on 6-WCe column	172
3.8.3.1. Loading of ^{99}Mo and ^{137}Cs onto the 6-WCe column	172
3.8.3.2. Washing and conditioning of the 6-WCe column for $^{99\text{m}}\text{Tc}$ elution	174
3.8.3.3. Quality control of $^{99\text{m}}\text{Tc}$ eluates	174

	Page
3.8.3.3.1. Elution performance of ^{99m}Tc	174
3.8.3.3.1.1. Elution profiles of ^{99m}Tc	178
3.8.3.3.1.2. Elution yield of ^{99m}Tc	178
3.8.3.3.2. Radionuclidic purity of ^{99m}Tc	180
3.8.3.3.3. Radiochemical purity of ^{99m}Tc	180
3.8.3.3.4. Chemical purity of ^{99m}Tc	180
3.8.3.3.5. pH-value of ^{99m}Tc eluates	184
3.8.3.3.6. Reproducibility of the $^{99}\text{Mo}/^{99m}\text{Tc}$ generator	184
3.8.3.4. Washing and conditioning of the 6-WCe column for ^{137m}Ba elution	185
3.8.3.5. Quality control of ^{137m}Ba eluates	185
3.8.3.5.1. Elution performance of ^{137m}Ba	185
3.8.3.5.1.1. Elution profiles of ^{137m}Ba	185
3.8.3.5.1.2. Elution yield of ^{137m}Ba	189
3.8.3.5.2. Radionuclidic purity of ^{137m}Ba	189
3.8.3.5.3. Chemical purity of ^{137m}Ba	193
3.8.3.5.4. pH-value of ^{137m}Ba eluates	193
3.8.3.5.5. Reproducibility of the $^{137}\text{Cs}/^{137m}\text{Ba}$ generator	193
REFERENCES	198