CASP 13 internal ID: T0987/X0987

Cross-linking mass spectrometry data

**Protein information (as provided)**

CASP13 internal ID: regular target T0987, XL-MS assisted X0987.

Protein Name: Esp405

Organism Name: Enterococcus faecalis

Amino acid sequence:

10 20 30 40 50 60   
NAQMGEGRLA NYSASGNTFQ ENPGYTKNYN FSDLQFNPKA ITGDVLQGNT IDFEVYGKHN   
  
 70 80 90 100 110 120   
IAASTANWEI RLQLDERLAQ YVEKIQVDPK KGVGNSRRTF VRINDSLGRP TNIWKVNYIR   
  
 130 140 150 160 170 180   
ANDGLFAGAE TTDTQTAPNG VITFEKNLDE IFKEIGADNL KSDRLMYRIY LVSHQDDDKI   
  
 190 200 210 220 230 240   
VPGIESTGYF LTDQDDFYNK LDVSENNSDQ FKHGSVNTKY EEANIQTKDG SGSTGANGAI   
  
 250 260 270 280 290 300   
ILDHKLTKEK NFSYSTSAKG TPWYANYKID ERLVPYVSGI QMHMVQADKV AYNVAFESGK   
  
 310 320 330 340 350 360   
KVADLAIERR EGHENYGMGS ITDNDLTKLI DFANASPRPI VVRYVLQLTK PLDEILEEMK   
  
 370 380 390 400 410   
AADKIEENAP FGEDFIFDSW LSDTNKKLIQ NTYGTGYYYL QDIDGLEVLF Q

**Methods**

The target protein or protein complex was cross-linked and analyzed by mass spectrometry as described here:

*Lysine-specific chemical cross-linking of protein complexes and identification of cross-linking sites using LC-MS/MS and the xQuest/xProphet software pipeline*. Leitner, Walzthoeni and Aebersold. *Nature Protocols*, 2014. DOI: 10.1038/nprot.2013.168

*Chemical cross-linking/mass spectrometry targeting acidic residues in proteins and protein complexes*. Leitner, Joachimiak, Unverdorben, Walzthoeni, Frydman, Förster and Aebersold. *Proceedings of the National Academy of Sciences of the United States of America,* 2014. DOI: 10.1073/pnas.1320298111

The concentration of the protein or protein complex was adjusted to avoid over-cross-linking, e.g. introduction of non-native oligomerization states. All cross-linking reactions were followed by SDS-PAGE.

**Cross-links identified by mass spectrometry**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Intra-chain cross-links** | | | | | |
| **Protein1** | **Protein2** | **AbsPos1** | **AbsPos2** | **ld-Score\*** | **Chemistry\*\*** |
| Esp405 | Esp405 | 314 | 202 | 47.62 | PDH |
| Esp405 | Esp405 | 374 | 76 | 45.16 | PDH |
| Esp405 | Esp405 | 153 | 161 | 44.76 | DSS |
| Esp405 | Esp405 | 259 | 202 | 43.51 | ZL |
| Esp405 | Esp405 | 84 | 91 | 42.34 | DSS |
| Esp405 | Esp405 | 115 | 90 | 41.25 | DSS |
| Esp405 | Esp405 | 301 | 91 | 41.06 | DSS |
| Esp405 | Esp405 | 202 | 149 | 40.88 | PDH |
| Esp405 | Esp405 | 153 | 202 | 39.94 | ZL |
| Esp405 | Esp405 | 202 | 158 | 39.36 | PDH |
| Esp405 | Esp405 | 205/202 | 149 | 38.86 | PDH |
| Esp405 | Esp405 | 363 | 373 | 38.71 | PDH |
| Esp405 | Esp405 | 354/353 | 222 | 38.54 | PDH |
| Esp405 | Esp405 | 161 | 250 | 38.51 | DSS |
| Esp405 | Esp405 | 297 | 301 | 38.36 | ZL |
| Esp405 | Esp405 | 250 | 90 | 38.33 | DSS |
| Esp405 | Esp405 | 115 | 153 | 38.28 | DSS |
| Esp405 | Esp405 | 328 | 301 | 38.24 | DSS |
| Esp405 | Esp405 | 212 | 91 | 38.14 | DSS |
| Esp405 | Esp405 | 350 | 360 | 38.14 | DSS |
| Esp405 | Esp405 | 259 | 91 | 38.05 | DSS |
| Esp405 | Esp405 | 115 | 84 | 37.74 | DSS |
| Esp405 | Esp405 | 202 | 250 | 37.67 | ZL |
| Esp405 | Esp405 | 353 | 222 | 37.67 | PDH |
| Esp405 | Esp405 | 158 | 76 | 36.77 | PDH |
| Esp405 | Esp405 | 115 | 301 | 36.39 | DSS |
| Esp405 | Esp405 | 153 | 268 | 36.22 | DSS |
| Esp405 | Esp405 | 250 | 91 | 36.07 | DSS |
| Esp405 | Esp405 | 314 | 301 | 35.92 | ZL |
| Esp405 | Esp405 | 153 | 250 | 35.52 | DSS |
| Esp405 | Esp405 | 259 | 205 | 35.5 | ZL |
| Esp405 | Esp405 | 219 | 91 | 35.41 | DSS |
| Esp405 | Esp405 | 44 | 52 | 35.29 | PDH |
| Esp405 | Esp405 | 83 | 76 | 35.18 | PDH |
| Esp405 | Esp405 | 259 | 301 | 35.09 | DSS |
| Esp405 | Esp405 | 44 | 250 | 35.05 | ZL |
| Esp405 | Esp405 | 268 | 91 | 34.99 | DSS |
| Esp405 | Esp405 | 91 | 88 | 34.98 | ZL |
| Esp405 | Esp405 | 133 | 250 | 34.85 | ZL |
| Esp405 | Esp405 | 115 | 91 | 34.78 | DSS |
| Esp405 | Esp405 | 259 | 90 | 34.27 | DSS |
| Esp405 | Esp405 | 212 | 250 | 34.14 | DSS |
| Esp405 | Esp405 | 161 | 91 | 34.03 | DSS |
| Esp405 | Esp405 | 250 | 259 | 34.01 | DSS |
| Esp405 | Esp405 | 33 | 250 | 33.72 | ZL |
| Esp405 | Esp405 | 202 | 161 | 33.51 | ZL |
| Esp405 | Esp405 | 386 | 153 | 33.13 | DSS |
| Esp405 | Esp405 | 161 | 76 | 32.4 | ZL |
| Esp405 | Esp405 | 259 | 268 | 32.25 | DSS |
| Esp405 | Esp405 | 245 | 219 | 31.92 | DSS |
| Esp405 | Esp405 | 228 | 300 | 31.9 | DSS |
| Esp405 | Esp405 | 146 | 153 | 31.69 | DSS |
| Esp405 | Esp405 | 161 | 301 | 31.63 | DSS |
| Esp405 | Esp405 | 250 | 177 | 31.55 | ZL |
| Esp405 | Esp405 | 259 | 153 | 31.46 | DSS |
| Esp405 | Esp405 | 268 | 301 | 31.15 | DSS |
| Esp405 | Esp405 | 58 | 250 | 30.53 | DSS |
| Esp405 | Esp405 | 268 | 250 | 30.34 | DSS |
| Esp405 | Esp405 | 205 | 150 | 29.83 | PDH |
| Esp405 | Esp405 | 245 | 212 | 29.16 | DSS |
| Esp405 | Esp405 | 245 | 250 | 28.3 | DSS |
| Esp405 | Esp405 | 115 | 250 | 28.04 | DSS |
| Esp405 | Esp405 | 154 | 75 | 27.96 | PDH |
| Esp405 | Esp405 | 259 | 161 | 27.65 | DSS |
| Esp405 | Esp405 | 364 | 350 | 27.01 | DSS |
| Esp405 | Esp405 | 205 | 158 | 26.9 | PDH |
| Esp405 | Esp405 | 115 | 161 | 26.81 | DSS |
| Esp405 | Esp405 | 364 | 153 | 26.31 | DSS |
| Esp405 | Esp405 | 245 | 161 | 26.07 | DSS |

\* The score is a measure of confidence for the identification of the two connected peptides (i.e. computational assignment) that are identified by MS (the higher, the better). It is generally NOT correlated with the distance between the cross-linked residues. In addition, physicochemical properties of the peptides may affect the identification, so that some cross-linked peptides intrinsically have lower scores.

For the reported data, we expect a **false positive rate of identification of approximately 5%.**

\*\*Cross-linking chemistries:

DSS: disuccinimidyl suberate – a lysine specific cross-linker.  
ZL: Zero-length cross-links formed between lysine and an aspartate/glutamate residue by the coupling reagent 4-(4,6-dimethoxy-1,3,5- triazin-2-yl)-4-methylmorpholinium chloride (DMTMM).  
PDH: pimelic acid dihydrazide – a carboxylic acid specific cross-linker (aspartate and glutamate).

For experimentally observed distance restraints, see the following plot (ADH is not used here):



(taken from Leitner et al., PNAS, 2014)

**Sub-optimal sequence regions for conventional cross-linking mass spectrometry**

Red residues: Lysine residues. Can be cross-linked by DSS and the zero-length cross-linking reagent DMTMM. Cleavage sites for trypsin (protease used in the experimental process).

Black residues: Arginine residues. Cleavage site for trypsin (protease used in the experimental process).

Green residues: Aspartate and glutamate residues. Can be cross-linked by PDH and the zero-length cross-linking reagent DMTMM.

Residues highlighted in yellow are sub-optimal regions for mass spectrometric analysis.

(NO SUBOPTIMAL REGIONS IDENTIFIED)

10 20 30 40 50 60

NAQMG**E**G**R**LA NYSASGNTFQ **E**NPGYT**K**NYN FS**D**LQFNP**K**A ITG**D**VLQGNT I**D**F**E**VYG**K**HN

70 80 90 100 110 120

IAASTANW**E**I **R**LQL**DER**LAQ YV**EK**IQV**D**P**K K**GVGNS**RR**TF V**R**IN**D**SLG**R**P TNIW**K**VNYI**R**

130 140 150 160 170 180

AN**D**GLFAGA**E** TT**D**TQTAPNG VITF**EK**NL**DE** IF**KE**IGA**D**NL **K**S**DR**LMY**R**IY LVSHQ**DDDK**I

190 200 210 220 230 240

VPGI**E**STGYF LT**D**Q**DD**FYN**K** L**D**VS**E**NNS**D**Q F**K**HGSVNT**K**Y **EE**ANIQT**KD**G SGSTGANGAI

250 260 270 280 290 300

IL**D**H**K**LT**KEK** NFSYSTSA**K**G TPWYANY**K**I**D ER**LVPYVSGI QMHMVQA**DK**V AYNVAF**E**SG**K**

310 320 330 340 350 360

**K**VA**D**LAI**ERR E**GH**E**NYGMGS IT**D**N**D**LT**K**LI **D**FANASP**R**PI VV**R**YVLQLT**K** PL**DE**IL**EE**M**K**

370 380 390 400 410

AA**DK**I**EE**NAP FG**ED**FIF**D**SW LS**D**TN**KK**LIQ NTYGTGYYYL Q**D**I**D**GL**E**VLF Q

**Residues labelled by cross-linking reagents**

Red residues: Residues labeled by either by DSS (Lysine reactive) or PDH (carboxylic acid reactive), but not cross-linked. These residues are expected to be solvent exposed.

Green residues: Reactive unlabeled residues.

Notes:

Absence of a modification may also mean that the corresponding modified peptide is present, but not identified by MS.

10 20 30 40 50 60

NAQMG**E**GRLA NYSASGNTFQ **E**NPGYT**K**NYN FS**D**LQFNP**K**A ITG**D**VLQGNT I**D**F**E**VYG**K**HN

70 80 90 100 110 120

IAASTANW**E**I RLQL**DE**RLAQ YV**EK**IQV**D**P**K K**GVGNSRRTF VRIN**D**SLGRP TNIW**K**VNYIR

130 140 150 160 170 180

AN**D**GLFAGA**E** TT**D**TQTAPNG VITF**EK**NL**DE** IF**KE**IGA**D**NL **K**S**D**RLMYRIY LVSHQ**DDDK**I

190 200 210 220 230 240

VPGI**E**STGYF LT**D**Q**DD**FYN**K** L**D**VS**E**NNS**D**Q F**K**HGSVNT**K**Y **EE**ANIQT**KD**G SGSTGANGAI

250 260 270 280 290 300

IL**D**H**K**LT**KEK** NFSYSTSA**K**G TPWYANY**K**I**D E**RLVPYVSGI QMHMVQA**DK**V AYNVAF**E**SG**K**

310 320 330 340 350 360

**K**VA**D**LAI**E**RR **E**GH**E**NYGMGS IT**D**N**D**LT**K**LI **D**FANASPRPI VVRYVLQLT**K** PL**DE**IL**EE**M**K**

370 380 390 400 410

AA**DK**I**EE**NAP FG**ED**FIF**D**SW LS**D**TN**KK**LIQ NTYGTGYYYL Q**D**I**D**GL**E**VLF Q