**Supplementary File 2: List of plasmids used**

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| **Plasmids** | **Description** | **Reference** |
| pZS21 | PLtet-dependent expression vector | (Lutz and Bujard, 1997) |
| pZS21::*His-bamA* | Encodes full-length BamA with an N-terminal His8 tag | (Kim et al., 2007) |
| pZS21::*His-bamAG655Am* | pZS21::*His-bamA* with G655Amber | This study |
| pZS21::*His-bamAS657Am* | pZS21::*His-bamA* with S657Amber | This study |
| pZS21::*His-bamAT659Am* | pZS21::*His-bamA* with G659Amber | This study |
| pZS21::*His-bamAN666Am* | pZS21::*His-bamA* with N666Amber | This study |
| pZS21::*His-bamAI668Am* | pZS21::*His-bamA* with I668Amber | This study |
| pZS21::*His-bamAN427Am* | pZS21::*His-bamA* with N427Amber | This study |
| pZS21::*His-bamAY432Am* | pZS21::*His-bamA* with Y432Amber | This study |
| pZS21::*His-bamAT434Am* | pZS21::*His-bamA* with T434Amber | This study |
| pZS21::*His-bamAE435Am* | pZS21::*His-bamA* with E435Amber | This study |
| pZS21::*His-bamAS439Am* | pZS21::*His-bamA* with S439Amber | This study |
| pZS21::*His-bamAQ441Am* | pZS21::*His-bamA* with Q441Amber | This study |
| pZS21::*His-bamAY468Am* | pZS21::*His-bamA* with Y468Amber | This study |
| pZS21::*His-bamAE470Am* | pZS21::*His-bamA* with E470Amber | This study |
| pZS21::*His-bamAL471Am* | pZS21::*His-bamA* with L471Amber | This study |
| pZS21::*His-bamAR488Am* | pZS21::*His-bamA* with R488Amber | This study |
| pZS21::*His-bamAF490Am* | pZS21::*His-bamA* with F490Amber | This study |
| pZS21::*His-bamAN492Am* | pZS21::*His-bamA* with N492Amber | This study |
| pZS21::*His-bamAF494Am* | pZS21::*His-bamA* with F494Amber | This study |
| pZS21::*His-bamAN501Am* | pZS21::*His-bamA* with N501Amber | This study |
| pZS21::*His-bamAT511Am* | pZS21::*His-bamA* with T511Amber | This study |
| pZS21::*His-bamAG528Am* | pZS21::*His-bamA* with G528Amber | This study |
| pZS21::*His-bamAG530Am* | pZS21::*His-bamA* with G530Amber | This study |
| pZS21::*His-bamAD569Am* | pZS21::*His-bamA* with D569Amber | This study |
| pZS21::*His-bamAK610Am* | pZS21::*His-bamA* with K610Amber | This study |
| pZS21::*His-bamAD614Am* | pZS21::*His-bamA* with D614Amber | This study |
| pZS21::*His-bamAT615Am* | pZS21::*His-bamA* with T615Amber | This study |
| pZS21::*His-bamAG655Am* | pZS21::*His-bamA* with G655Amber | This study |
| pZS21::*His-bamAS657Am* | pZS21::*His-bamA* with S657Amber | This study |
| pZS21::*His-bamAT659Am* | pZS21::*His-bamA* with G659Amber | This study |
| pZS21::*His-bamAN666Am* | pZS21::*His-bamA* with N666Amber | This study |
| pZS21::*His-bamAI668Am* | pZS21::*His-bamA* with I668Amber | This study |
| pZS21::*His-bamAQ803Am* | pZS21::*His-bamA* with Q803Amber | This study |
| pZS21::*His-bamAF804Am* | pZS21::*His-bamA* with F804Amber | This study |
| pZS21::*His-bamAN805Am* | pZS21::*His-bamA* with N805Amber | This study |
| pZS21::*His-BamAS439C* | pZS21::*His-bamA* with S439C | This study |
| pZS21::*His-BamAN666C* | pZS21::*His-bamA* with N666C | This study |
| pTrc99a | Ptrp/lac-dependent expression vector | (Amann et al., 1988) |
| pTrc99a::*lptD-FLAG* | Encodes full-length LptD with a C-terminal FLAG3 tag | This study |
| pTrc99a::*lptD4213-FLAG* | Encodes LptD4213 with a C-terminal FLAG3 tag | This study |
| pTrc99a::*lptD4213-FLAGL245C* | pTrc99a::*lptD4213-FLAG* with L245C | This study |
| pTrc99a::*lptD4213-FLAGH262C* | pTrc99a::*lptD4213-FLAG* with H262C | This study |
| pTrc99a::*lptD4213-FLAGY291C* | pTrc99a::*lptD4213-FLAG* with Y291C | This study |
| pTrc99a::*lptD4213-FLAGA709C* | pTrc99a::*lptD4213-FLAG* with A709C | This study |
| pTrc99a::*lptD4213-FLAGE733C* | pTrc99a::*lptD4213-FLAG* with E733C | This study |
| pTrc99a::*lptD4213-FLAGN737C* | pTrc99a::*lptD4213-FLAG* with N737C | This study |
| pTrc99a::*FLAG-lamB* | Encodes full-length LamB with a N-terminal FLAG3 tag | This study |
| pTrc99a::*FLAG-ompF* | Encodes full-length OmpF with a N-terminal FLAG3 tag | This study |
| pZS21::*lptD-His* | Encodes full-length LptD with a C-terminal His8 tag | (Lee et al., 2018) |
| pZS21::*lptD-HisA233Am* | pZS21::*lptD-His* with A233Amber | This study |
| pZS21::*lptD-HisK234Am* | pZS21::*lptD-His* with K234Amber | This study |
| pZS21::*lptD-HisY235Am* | pZS21::*lptD-His* with Y235Amber | This study |
| pZS21::*lptD-HisT237Am* | pZS21::*lptD-His* with T237Amber | This study |
| pZS21::*lptD-HisT238Am* | pZS21::*lptD-His* with T238Amber | This study |
| pZS21::*lptD-HisY240Am* | pZS21::*lptD-His* with Y240Amber | This study |
| pZS21::*lptD-HisY244Am* | pZS21::*lptD-His* with Y244Amber | This study |
| pZS21::*lptD-HisY248Am* | pZS21::*lptD-His* with Y248Amber | This study |
| pZS21::*lptD-HisI259Am* | pZS21::*lptD-His* with I259Amber | This study |
| pZS21::*lptD-HisT260Am* | pZS21::*lptD-His* with T260Amber | This study |
| pZS21::*lptD-HisP261Am* | pZS21::*lptD-His* with P261Amber | This study |
| pZS21::*lptD-HisH262Am* | pZS21::*lptD-His* with H262Amber | This study |
| pZS21::*lptD-HisY263Am* | pZS21::*lptD-His* with Y263Amber | This study |
| pZS21::*lptD-HisW272Am* | pZS21::*lptD-His* with W272Amber | This study |
| pZS21::*lptD-HisE273Am* | pZS21::*lptD-His* with E273Amber | This study |
| pZS21::*lptD-HisN274Am* | pZS21::*lptD-His* with N274Amber | This study |
| pZS21::*lptD-HisE275Am* | pZS21::*lptD-His* with E275Amber | This study |
| pZS21::*lptD-HisF276Am* | pZS21::*lptD-His* with F276Amber | This study |
| pZS21::*lptD-HisL289Am* | pZS21::*lptD-His* with L289Amber | This study |
| pZS21::*lptD-HisD290Am* | pZS21::*lptD-His* with L290Amber | This study |
| pZS21::*lptD-HisY291Am* | pZS21::*lptD-His* with Y291Amber | This study |
| pZS21::*lptD-HisW311Am* | pZS21::*lptD-His* with W311Amber | This study |
| pZS21::*lptD-HisL312Am* | pZS21::*lptD-His* with L312Amber | This study |
| pZS21::*lptD-HisF313Am* | pZS21::*lptD-His* with F313Amber | This study |
| pZS21::*lptD-HisY314Am* | pZS21::*lptD-His* with Y314Amber | This study |
| pZS21::*lptD-HisW315Am* | pZS21::l*ptD-His* with W315Amber | This study |
| pZS21::*lptD-HisY678Am* | pZS21::*lptD-His* with Y678Amber | This study |
| pZS21::*lptD-HisQ684Am* | pZS21::*lptD-His* with Q684Amber | This study |
| pZS21::*lptD-HisV685Am* | pZS21::*lptD-His* with V685Amber | This study |
| pZS21::*lptD-HisY704Am* | pZS21::*lptD-His* with Y704Amber | This study |
| pZS21::*lptD-HisN708Am* | pZS21::*lptD-His* with N708Amber | This study |
| pZS21::*lptD-HisM716Am* | pZS21::*lptD-His* with M716Amber | This study |
| pZS21::*lptD-HisL717Am* | pZS21::*lptD-His* with L717Amber | (Lee et al., 2018) |
| pZS21::*lptD-HisG718Am* | pZS21::*lptD-His* with G718Amber | (Lee et al., 2018) |
| pZS21::*lptD-HisV719Am* | pZS21::*lptD-His* with V719Amber | This study |
| pZS21::*lptD-HisY721Am* | pZS21::*lptD-His* with Y721Amber | (Lee et al., 2018) |
| pZS21::*lptD-HisY726Am* | pZS21::*lptD-His* with MY726Amber | (Lee et al., 2018) |
| pZS21::*lptD-HisI728Am* | pZS21::*lptD-His* with I728Amber | This study |
| pZS21::*lptD-HisN737Am* | pZS21::*lptD-His* with N737Amber | This study |
| pZS21::*lptD-HisW739Am* | pZS21::*lptD-His* with W739Amber | This study |
| pZS21::*lptD-HisK743Am* | pZS21::*lptD-His* with K743Amber | This study |
| pZS21::*lptD-HisV747Am* | pZS21::*lptD-His* with V747Amber | This study |
| pZS21::*lptD-HisY748Am* | pZS21::*lptD-His* with Y748Amber | This study |
| pZS21::*lptD-HisD749Am* | pZS21::*lptD-His* with D749Amber | This study |
| pZS21::*lptD-HisI752Am* | pZS21::*lptD-His* with I752Amber | This study |
| pZS21::*lptD-HisF754Am* | pZS21::*lptD-His* with F754Amber | This study |
| pZS21::*lptD-HisN755Am* | pZS21::*lptD-His* with N755Amber | This study |
| pZS21::*lptD4213-His* | Encodes LptD4213 (Δ330-352) with a C-terminal His8 tag | (Lee et al., 2018) |
| pZS21::*lptD4213-HisA233Am* | pZS21::*lptD4213-His* with A233Amber | This study |
| pZS21::*lptD4213-HisK234Am* | pZS21::*lptD4213-His* with K234Amber | This study |
| pZS21::*lptD4213-HisY235Am* | pZS21::*lptD4213-His* with Y235Amber | This study |
| pZS21::*lptD4213-HisT237Am* | pZS21::*lptD4213-His* with T237Amber | This study |
| pZS21::*lptD4213-HisT238Am* | pZS21::*lptD4213-His* with T238Amber | This study |
| pZS21::*lptD4213-HisY240Am* | pZS21::*lptD4213-His* with Y240Amber | This study |
| pZS21::*lptD4213-HisY244Am* | pZS21::*lptD4213-His* with Y244Amber | This study |
| pZS21::*lptD4213-HisY248Am* | pZS21::*lptD4213-His* with Y248Amber | This study |
| pZS21::*lptD4213-HisI259Am* | pZS21::*lptD4213-His* with I259Amber | This study |
| pZS21::*lptD4213-HisT260Am* | pZS21::*lptD4213-His* with T260Amber | This study |
| pZS21::*lptD4213-HisP261Am* | pZS21::*lptD4213-His* with P261Amber | This study |
| pZS21::*lptD4213-HisH262m* | pZS21::*lptD4213-His* with H262Amber | This study |
| pZS21::*lptD4213-HisY263Am* | pZS21::*lptD4213-His* with Y263Amber | This study |
| pZS21::l*ptD4213-HisR266Am* | pZS21::*lptD4213-His* with R266Amber | This study |
| pZS21::*lptD4213-HisN269Am* | pZS21::*lptD4213-His* with N269Amber | This study |
| pZS21::*lptD4213-HisW272Am* | pZS21::*lptD4213-His* with W272Amber | This study |
| pZS21::*lptD4213-HisE273Am* | pZS21::*lptD4213-His* with E273Amber | This study |
| pZS21::*lptD4213-HisN274Am* | pZS21::*lptD4213-His* with N274Amber | This study |
| pZS21::*lptD4213-HisE275Am* | pZS21::*lptD4213-His* with E275Amber | This study |
| pZS21::*lptD4213-HisF276Am* | pZS21::*lptD4213-His* with F276Amber | This study |
| pZS21::l*ptD4213-HisL279Am* | pZS21::*lptD4213-His* with L279Amber | This study |
| pZS21::l*ptD4213-HisL286Am* | pZS21::*lptD4213-His* with L286Amber | This study |
| pZS21::*lptD4213-HisL289Am* | pZS21::*lptD4213-His* with L289Amber | This study |
| pZS21::*lptD4213-HisD290Am* | pZS21::*lptD4213-His* with L290Amber | This study |
| pZS21::*lpt4213D-HisY291Am* | pZS21::*lptD4213-His* with Y291Amber | This study |
| pZS21::*lptD4213-HisW311Am* | pZS21::*lptD4213-His* with W311Amber | This study |
| pZS21::*lptD4213-HisL312Am* | pZS21::*lptD4213-His* with L312Amber | This study |
| pZS21::*lptD4213-HisF313Am* | pZS21::*lptD4213-His* with F313Amber | This study |
| pZS21::*lptD4213-HisY314Am* | pZS21::*lptD4213-His* with Y314Amber | This study |
| pZS21::*lptD4213-HisW315Am* | pZS21::*lptD4213-His* with W315Amber | This study |
| pZS21::*lptD4213-HisY678Am* | pZS21::*lptD4213-His* with Y678Amber | This study |
| pZS21::*lptD4213-HisQ684Am* | pZS21::*lptD4213-His* with Q684Amber | This study |
| pZS21::*lptD4213-HisV685Am* | pZS21::*lptD4213-His* with V685Amber | This study |
| pZS21::*lptD4213-HisY704Am* | pZS21::*lptD4213-His* with Y704Amber | This study |
| pZS21::*lptD4213-HisN708Am* | pZS21::*lptD4213-His* with N708Amber | This study |
| pZS21::*lptD4213-HisM716Am* | pZS21::*lptD4213-His* with M716Amber | This study |
| pZS21::*lptD4213-HisL717Am* | pZS21::*lptD4213-His* with L717Amber | (Lee et al., 2018) |
| pZS21::*lptD4213-HisG718Am* | pZS21::*lptD4213-His* with G718Amber | (Lee et al., 2018) |
| pZS21::*lptD4213-HisV719Am* | pZS21::*lptD4213-His* with V719Amber | This study |
| pZS21::*lptD4213-HisY721Am* | pZS21::*lptD4213-His* with Y721Amber | (Lee et al., 2018) |
| pZS21::*lptD4213-HisY726Am* | pZS21::*lptD4213-His* with MY726Amber | (Lee et al., 2018) |
| pZS21::*lptD4213-HisI728Am* | pZS21::*lptD4213-His* with I728Amber | This study |
| pZS21::*lptD4213-HisN737Am* | pZS21::*lptD4213-His* with N737Amber | This study |
| pZS21::*lptD4213-HisW739Am* | pZS21::*lptD4213-His* with W739Amber | This study |
| pZS21::*lptD4213-HisK743Am* | pZS21::*lptD4213-His* with K743Amber | This study |
| pZS21::*lptD4213-HisV747Am* | pZS21::*lptD4213-His* with V747Amber | This study |
| pZS21::*lptD4213-HisY748Am* | pZS21::*lptD4213-His* with Y748Amber | This study |
| pZS21::*lptD4213-HisD749Am* | pZS21::*lptD4213-His* with D749Amber | This study |
| pZS21::*lptD4213-HisI752Am* | pZS21::*lptD4213-His* with I752Amber | This study |
| pZS21::*lptD4213-HisF754Am* | pZS21::*lptD4213-His* with F754Amber | This study |
| pZS21::*lptD4213-HisN755Am* | pZS21::*lptD4213-His* with N755Amber | This study |
| pZS21::*lptD4213-HisF276Am, N274I* | pZS21::*lptD4213-His* with F276Amber and N274I | This study |
| pZS21::*lptDΔD330-HisY244Am* | pZS21::*lptD ΔD330-His* with Y244Amber | This study |
| pET23/42 | pET23a(+) with multiple cloning sites of pET42a(+), PT7-dependent expression vector | (Wu et al., 2005) |
| pET23/42::*lptD* | Encodes full-length LptD | (Chng et al., 2010) |
| pET23/42::*lptDN274I* | pET23/42::*lptD* with N274I | This study |
| pET23/42::*lptD4213* | Encodes LptD4213 (Δ330-352) | This study |
| pET23/42::*lptD4213N274I* | pET23/42::*lptD4213* with N274I | This study |
| pET23/42::*lptD*Δ*D330* | pET23/42::*lptD* with ΔD330 | This study |
| pET23/42::*lptD*Δ*D330, N274I* | pET23/42::*lptD*Δ*D330* with N274I | This study |
| pET23/42::*lptD-FLAG* | Encodes full-length LptD with a C-terminal FLAG3 tag | (Chng et al., 2012) |
| pET23/42::*lptD4213-FLAG* | Encodes LptD4213 (Δ330-352) with a C-terminal FLAG3 tag | This study |
| pET23/42::*lptD*Δ*D330-FLAG* | pET23/42::*lptD-FLAG* with ΔD330 | This study |
| pCDFDuet | PT7-dependent dual expression vector | Novagen |
| pCDF::*bamA* | Encodes full-length BamA | (Lee et al., 2018) |
| pCDF::*bamAS436P* | pCDF::*bamA* with S436P | This study |
| pCDF::*bamAQ441R* | pCDF::*bamA* with Q441R | This study |
| pCDF::*bamAE470G* | pCDF::*bamA* with E470G | This study |
| pCDF::*bamAD512G* | pCDF::*bamA* with D512G | This study |
| pDS132 | *R6K* *ori*, *mobRP4*, *sacB*, CamR | (Philippe et al., 2004) |
| pDS132::*bamA* | Encodes full-length BamA | This study |
| pDS132::*bamAE470G* | pDS132::*bamA* with E470G | This study |

**Supplementary References:**

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