

# SHuffle® Express Competent *E. coli*



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## C3028H

6 x 0.05 ml/tube

Lot: 3

Store at  $-80^{\circ}\text{C}$

**CAUTION:** This product contains DMSO, a hazardous material. Review the MSDS before handling.

**Description:** Chemically competent *E. coli* B cells engineered to form disulfide bonded proteins in the cytoplasm.

### Features:

- Transformation efficiency:  $1 \times 10^7$  cfu/ $\mu\text{g}$  pUC19 DNA
- Engineered *E. coli* B strain to promote disulfide bond formation in the cytoplasm
- Expresses constitutively a chromosomal copy of the disulfide bond isomerase DsbC
- DsbC promotes the correction of mis-oxidized proteins into their correct form (1,3)
- The cytoplasmic DsbC is also a chaperone that can assist in the folding of proteins that do not require disulfide bonds (4)
- Enhanced BL21 derivative
- Activity of nonspecific endonuclease I (*endA1*) eliminated for highest quality plasmid preparations
- Deficient in proteases Lon and OmpT
- Resistance to phage T1 (*fhuA2*)

### Reagents Supplied:

6 x 0.05 ml/tube of chemically competent SHuffle Competent *E. coli* cells (Store at  $-80^{\circ}\text{C}$ )

### Quality Control Assays

**Transformation Efficiency:** 100  $\mu\text{g}$  of pUC19 plasmid DNA was used to transform one tube of SHuffle® Competent *E. coli* following the high efficiency protocol provided.  $1 \times 10^7$  colonies formed/ $\mu\text{g}$  after an overnight incubation on LB-ampicillin plates at  $37^{\circ}\text{C}$ .

**Disulfide bond formation:** The *Serratia marcescens* extracellular nuclease NucA requires disulfide bonds for its stability. When expressed cytoplasmically at  $37^{\circ}\text{C}$  in *E. coli*, NucA is toxic to cells only in its oxidized disulfide-bonded state. Transformation of a plasmid that expresses a MBP-NucA fusion in the cytoplasm was used to test the ability of SHuffle strains to form cytoplasmic disulfide bonds. 100  $\mu\text{g}$  pMBP-NucA was used to transform SHuffle, resulting in no transformants. Empty pMAL vector was used to calculate transformation efficiency and the wild type parent of SHuffle was used as a control.

Untransformed cells were tested for resistance to phage  $\phi 80$ , a standard test for resistance to phage T1, and sensitivity to ampicillin, chloramphenicol, kanamycin, streptomycin and tetracycline. Cells are resistant to spectinomycin.

### High Efficiency Transformation Protocol

Perform steps 1–7 in the tube provided.

1. Thaw a tube of SHuffle Competent *E. coli* cells on ice for 10 minutes.
2. Add 1–5  $\mu\text{l}$  containing 1  $\text{pg}$ –100  $\text{ng}$  of plasmid DNA to the cell mixture. Carefully flick the tube 4–5 times to mix cells and DNA. **Do not vortex.**
3. Place the mixture on ice for 30 minutes. Do not mix.

**STORAGE AND HANDLING:** Competent cells should be stored at  $-80^{\circ}\text{C}$ . Storage at  $-20^{\circ}\text{C}$  will result in a significant decrease in transformation efficiency. Cells lose efficiency whenever they are warmed above  $-80^{\circ}\text{C}$ , even if they do not thaw.

4. Heat shock at exactly  $42^{\circ}\text{C}$  for exactly 30 seconds. Do not mix.
5. Place on ice for 5 minutes. Do not mix.
6. Pipette 950  $\mu\text{l}$  of room temperature SOC into the mixture.
7. Place at  $30^{\circ}\text{C}$  for 60 minutes. Shake vigorously (250 rpm) or rotate.
8. Warm selection plates to  $30^{\circ}\text{C}$ .
9. Mix the cells thoroughly by flicking the tube and inverting, then perform several 10-fold serial dilutions in SOC.
10. Spread 50–100  $\mu\text{l}$  of each dilution onto a selection plate and incubate overnight at  $30^{\circ}\text{C}$ . Alternatively, incubate at  $25^{\circ}\text{C}$  for 48 hours.

### 5 Minute Transformation Protocol

A shortened transformation protocol resulting in approximately 10% efficiency compared to the standard protocol may be suitable for applications where a reduced total number of transformants is acceptable. Follow the High Efficiency Transformation Protocol above with the following changes:

1. Steps 3 and 5 are reduced to 2 minutes.
2. Omit outgrowth (step 7) completely for ampicillin-resistant plasmids or reduce the outgrowth time for other selective media as appropriate.

### Protocol for Expression Using SHuffle

1. Transform expression plasmid into SHuffle. Plate on antibiotic selection plates and incubate 24 hours at  $30^{\circ}\text{C}$ .
2. Resuspend a single colony in 10 ml liquid medium with antibiotic.
3. Incubate at  $30^{\circ}\text{C}$  until  $\text{OD}_{600}$  reaches 0.4–0.8.
4. Add the appropriate inducer, e.g. 40  $\mu\text{l}$  of a 100 mM stock of IPTG. Incubate for 4 hours at  $30^{\circ}\text{C}$  or  $16^{\circ}\text{C}$  overnight.
5. Check for expression either by Coomassie stained protein gel, Western Blot or activity assay. Check expression in both the total cell extract (soluble + insoluble) and the soluble fraction alone.
6. For large scale, inoculate 1 L of liquid medium (with antibiotic) with a freshly grown colony or 10 ml of freshly grown culture. Incubate at  $30^{\circ}\text{C}$  until reaches 0.4–0.8. Add the appropriate inducer, e.g. IPTG to 0.4 mM. Induce 4 hours or  $16^{\circ}\text{C}$  overnight.

### Transformation Protocol Variables

**Thawing:** Cells are best thawed on ice and DNA added as soon as the last bit of ice in the tube disappears. Cells can also be thawed by hand, but warming above  $0^{\circ}\text{C}$  will decrease the transformation efficiency.

**Incubation of DNA with Cells on Ice:** For maximum transformation efficiency, cells and DNA should be incubated together on ice for 30 minutes. Expect a 2-fold loss in transformation efficiency for every 10 minutes you shorten this step.

**Heat Shock:** Both the temperature and the timing of the heat shock step are important and specific to the transformation volume and vessel. Using the transformation tube provided, 30 seconds at  $42^{\circ}\text{C}$  is optimal.

**Outgrowth:** Outgrowth at  $30^{\circ}\text{C}$  for 1 hour is best for cell recovery and for expression of antibiotic resistance. Expect a 2-fold loss in transformation efficiency for every 15 minutes you shorten this step. SOC gives 2-fold higher transformation efficiency than LB medium; and incubation with shaking or rotating the tube gives 2-fold higher transformation efficiency than incubation without shaking.

**Plating:** Selection plates can be used warm or cold, wet or dry without significantly affecting the transformation efficiency. However, warm, dry plates are easier to spread and allow for the most rapid colony formation.

### DNA Contaminants to Avoid

Contaminant	Removal Method
Detergents	Ethanol precipitate
Phenol	Extract with chloroform and ethanol precipitate
Ethanol or Isopropanol	Dry pellet before resuspending
PEG*	Column purify or phenol/chloroform extract and ethanol precipitate
DNA binding proteins* (e.g. Ligase)	Column purify or phenol/chloroform extract and ethanol precipitate

\* Ideally, DNA for transformation should be purified and resuspended in water or TE. However, up to 10  $\mu\text{l}$  of DNA directly from a ligation mix can be used with only a two-fold loss of transformation efficiency. Where it is necessary to maximize the number of transformants (e.g. a library), a purification step, either a spin column or phenol/chloroform extraction and ethanol precipitation should be added.

CERTIFICATE OF ANALYSIS

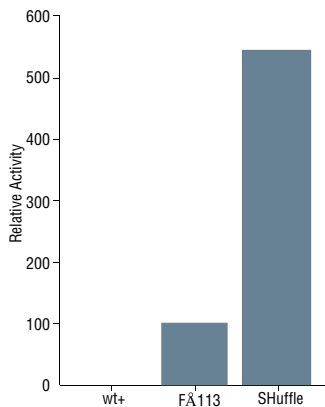
## Solutions/Recipes

SOB:		SOC:	
2%	Vegetable peptone (or Tryptone)	SOB + 20 mM Glucose	
0.5%	Yeast Extract	LB agar:	
10 mM	NaCl	1%	Tryptone
2.5 mM	KCl	0.5%	Yeast Extract
10 mM	MgCl <sub>2</sub>	0.17 M	NaCl
10 mM	MgSO <sub>4</sub>	1.5%	Agar

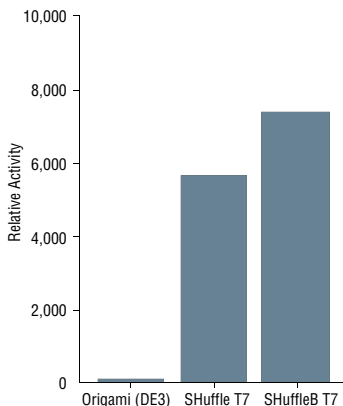
## Antibiotics for plasmid selection

Antibiotic	Working Concentration
Ampicillin	100 µg/ml
Carbenicillin	100 µg/ml
Chloramphenicol	33 µg/ml
Kanamycin	30 µg/ml
Streptomycin	25 µg/ml
Tetracycline	15 µg/ml

**Genotype:** *thua2 [lon] ompT ahpC gal λatt::pNEB3-r1-cDsbC (Spec<sup>R</sup>, lac<sup>P</sup>) ΔtrxB sulA11 R(mcr-73::miniTn10--Tet<sup>S</sup>)2 [dcm] R(zgb-210::Tn10 --Tet<sup>S</sup>) endA1 Δgor Δ(mcrC-mrr)114::IS10*



**Figure 1, vtPA activity assayed from crude lysates:** Truncated tissue plasminogen activator (vtPA), which contains nine disulfide bonds when folded and oxidized correctly, was expressed from a pTrc99a plasmid in the cytoplasm of *E. coli* cells. After induction, cells were harvested and crude cell lysates were prepared. vtPA was assayed using a chromogenic substrate Chromozym t-PA (Roche #11093037001) and standardized to protein concentration using Bradford reagent. *E. coli* wt+ cells are DHB4, which is the parent of FA113 (Origami™).



**Figure 2, PfCHT1 chitinase activity assayed from crude lysates:** *Plasmodium falciparum* chitinase (PfCHT1) with three cysteines were expressed from a plasmid under the regulation of T7 promoter. After induction, cells were harvested and crude cell lysates were prepared. PfCHT1 was assayed using a chromogenic substrate (CalBioChem #474550) and standardized to protein concentration using Bradford reagent.

## Strain Properties

The properties of this strain that contribute to its usefulness as a protein expression strain are described below. The genotypes underlying these properties appear in parentheses.

**Disulfide bond formation in the cytoplasm:** Normally reductases in the *E. coli* cytoplasm keep cysteines in their reduced form, thereby reducing any disulfide bond that may form in this compartment. SHuffle has deletions of the genes for glutaredoxin reductase and thioredoxin reductase ( $\Delta gor \Delta trxB$ ), which allows disulfide bonds to form in the cytoplasm. This combination of mutations is normally lethal, but the lethality is suppressed by a mutation in the peroxiredoxin enzyme (*ahpC*<sup>\*</sup>). In addition, SHuffle expresses a version of the periplasmic disulfide bond isomerase DsbC which lacks its signal sequence, retaining it in the cytoplasm. This enzyme has been shown to act on proteins with multiple disulfide bonds, to correct mis-oxidized bonds and promote proper folding. The gene for the cytoplasmic DsbC is present on the chromosome.

**Endonuclease I Deficient (*endA1*):** The periplasmic space of wild type *E. coli* cells contains a nonspecific endonuclease. Extreme care must be taken to avoid degradation of plasmids prepared from these cells. The *endA* mutation deletes this endonuclease and can significantly improve the quality of plasmid preparations.

**Protease Deficient (*[lon] ompT*):** *E. coli* B strains are “naturally” deficient in the *lon* protease which in K-12 strains serves to degrade misfolded proteins and to prevent some cell cycle-specific proteins from accumulating. The *OmpT* protease resides at the surface of wild type *E. coli* in both K-12 and B strains, presumably helping the cells to derive amino acids from their external environment. Cells deficient in both these proteases are much more amenable to the production of proteins from cloned genes. Mutations of other genes can help to ameliorate the sometimes-deleterious effects of these protease defects (e.g. *sulA*, below).

**T1 Phage Resistant (*thua2*):** T1, an extremely virulent phage requires the *E. coli* ferric hydroxamate uptake receptor for infectivity. Deletion of this gene confers resistance to this type of phage, but does not significantly affect the transformation or growth characteristics of the cell.

**Usage Note:** \*NEB recommends using SHuffle Express strains for best performance\*

## References

1. Bessette, P.H. et al. (1999) *Proc. Natl. Acad. Sci. USA*, 96, 13703–13708.
2. Qiu, J., Swartz, J.R. and Georgiou, G. (1998) *Appl. Environ. Microbiol.*, 64, 4891–4896.
3. Levy, R. et al. (2001) *Protein Expr. Purif.*, 23, 338–347.
4. Chen, J. et al. (1999) *J. Biol. Chem.*, 274, 19601–19605.
5. Boyd, D. et al. (2000) *J. Bacteriol.*, 182, 842–847.