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四溴双酚A对斑马鱼胚胎体内外发育的毒性效应

Toxic effects of TBBPA on *in vivo* and *in vitro* developments in the zebrafish (*Danio rerio*) embryos

关键词: [四溴双酚A](#) [斑马鱼](#) [胚胎发育](#) [毒性](#)

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摘要: 四溴双酚A(Tetrabromobisphenol A,TBBPA)是广泛使用的溴阻燃剂,在环境中普遍存在.采用斑马鱼胚胎体内外微环境模拟实验,研究了TBBPA对斑马鱼(*Danio rerio*)胚胎体内外发育的影响.结果发现,斑马鱼胚胎直接暴露在TBBPA溶液中,会造成胚胎心包囊水肿、尾部延伸不全等畸形或使胚胎死亡;当TBBPA浓度高于 $1.6 \text{ mg} \cdot \text{L}^{-1}$ 时,处理斑马鱼胚胎的致死率显著升高,与对照组有极显著差异($p < 0.01$),且致死效应主要发生在24 h内.当TBBPA浓度为 $6.4 \text{ mg} \cdot \text{L}^{-1}$ 时,斑马鱼胚胎在48 h内全部死亡.在TBBPA浓度大于 $0.4 \text{ mg} \cdot \text{L}^{-1}$ 的各组中,24 h内斑马鱼胚胎在20 s内的活动频率明显降低;当胚胎直接接触TBBPA 48 h,表现出的主要毒性效应为胚胎心包囊水肿,但胚胎的心率没观察到异常变化.当斑马鱼胚胎发育到72 h时,TBBPA引起斑马鱼胚胎毒性的主要特征是心包囊水肿和脊柱畸形.另外,TBBPA处理后斑马鱼胚胎的孵化率和生存率均显著降低,这表明斑马鱼胚胎直接暴露在TBBPA污染的环境中,会出现明显的发育障碍,主要表现为心脏功能受损和致死效应,这些毒性特征有显著的剂量-效应关系.当成年亲代斑马鱼暴露在TBBPA溶液($1.5 \text{ mg} \cdot \text{L}^{-1}$)中3~7 d后,子代胚胎的发育表现出明显的毒性效应,其胚胎发育到24 h和72 h时的致死率均呈现一定的时间-效应关系;72 h时的死亡率与对照组有极显著差异,子代胚胎的孵化率降低,但没有统计学差异;但子代胚胎的致畸率却显著升高,并呈现显著差异.研究结果表明,水体中残留的TBBPA对体内外斑马鱼胚胎的发育均有直接影响,对于鱼类的生殖和发育具有潜在的危害.

Abstract: Tetrabromobisphenol A (TBBPA) is a widely used brominated flame retardant that is present widely in the environment. The developmental toxicity effects of TBBPA on the zebrafish (*Danio rerio*) embryos were studied both *in vitro* and *in vivo*. The results showed that exposure to water-borne TBBPA would cause teratogenic effects and death of zebrafish embryos. The teratogenic defects included pericardial edema, hemoglutinations and axial malformation. The lethality rate significantly increased when the embryos were treated with higher concentrations of TBBPA. Furthermore, the death of zebrafish embryos mainly happened in 24 h post-fertilization (hpf). The zebrafish embryos exposed to $6.4 \text{ mg} \cdot \text{L}^{-1}$ TBBPA were all dead during 48 hpf. The activities of spontaneous movement of zebrafish embryos exposed to different TBBPA concentrations higher than $0.4 \text{ mg} \cdot \text{L}^{-1}$ decreased in 20s. The main toxic effect to the embryos in 48 hpf was pericardial edema. No difference in the heart rates of embryos was observed between the control group and treated groups. The main toxic effect for the embryos in 72 h was pericardial edema and curved trunk. The hatching rates and survival rates were significantly decreased. These results suggested that TBBPA in the water were toxic directly to zebrafish embryos' early development in a dose-response manner. The lethality of offspring embryos was increased at the endpoints of 24 h and 72 h in a time-response manner when the adult zebrafish were exposed to $1.5 \text{ mg} \cdot \text{L}^{-1}$ TBBPA for 3~7 days. The lethality rate showed significant difference in 72 hpf between TBBPA treated groups and the control group *in vivo*. The hatching rates of offspring embryos decreased when adult zebrafish were treated with TBBPA, however, no significant difference was observed. The teratogenesis rates of offspring embryos significantly increased, and showed marked difference between the treated groups and the control groups. The results indicated that TBBPA residue in water was potentially hazardous to the development of fishes.

Key words: [tetrabromobisphenol A](#) [zebrafish](#) [embryo development](#) [toxicity](#)

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